COMBUSTION

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DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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October, 1943

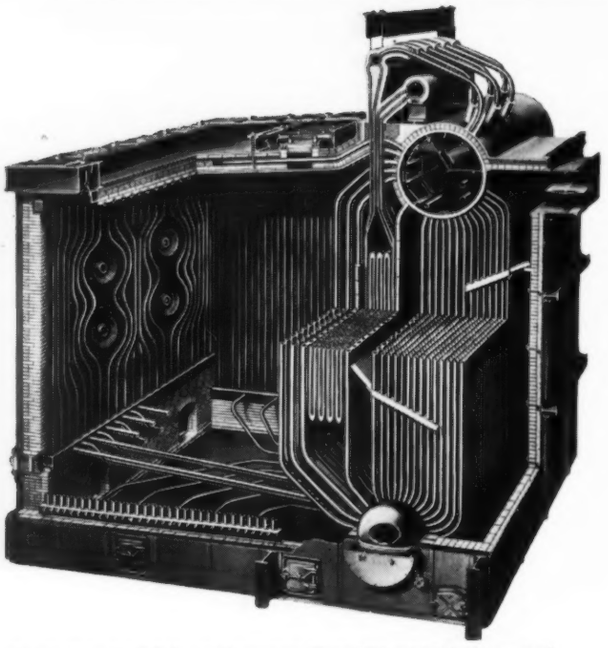
Courtesy of Albert Kahn Assoc. Arch. & Engrs. Inc. *Photo released by War Department*

Power Plant of Curtiss-Wright Corporation (see page 44)

Addition to Capacity and Modernization of the MARYSVILLE POWER HOUSE

Chemical De-scaling of Boilers and Power Plant Equipment

In *Continuous* Operation for its First 9 Months of Service



Sectional view of a C-E Steam Generator, Type VU, which is the type of unit responsible for the notable performance record described below.

Another Victory Unit speeds war production

Here's the most recent VU Steam Generator to prove the aptness of its wartime name — Victory Unit*. In a large Canadian aluminum plant, which is operating at full speed to produce increased quantities of its vital product, this VU Unit was first placed in service during March 1942. It was taken off the line for its *first* inspection in December 1942 *after 9 months of continuous operation.*

During this entire period the Victory Unit, designed for 131,000 lb maximum continuous output, generated an average of 120,000 lb of steam per hr. The peak load was 155,000 lb of steam per hr which was sustained for relatively long periods as is indicated by *average daily outputs* as high as 133,000 lb of steam per hr.

The inherent quality of the VU Unit is demonstrated by the report of the company on the findings of the first inspection. The boiler was in exceptionally good condition. Drum, tubes and headers were free of scale and very clean except for a slight sludge deposit which was easily washed out.

The furnace, boiler passes and preheater were so clean that they required but little attention. Except for repacking of valves and the normal replacement of those mill parts subjected to severe wear, no repairs were necessary.

Thus the design features of the VU Steam Generator and the quality of its construction help once again to minimize "time out" for inspection and maintenance so that the production of a vital war commodity may continue apace. Hence the appropriateness of the wartime name — Victory Unit.

A-727-A

*Labelled The Victory Unit many months ago by a member of our Engineering Department who was impressed by the number of these units going into war plants.

C-E

COMBUSTION ENGINEERING

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FIFTEEN NUMBER FOUR

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FOR OCTOBER 1943

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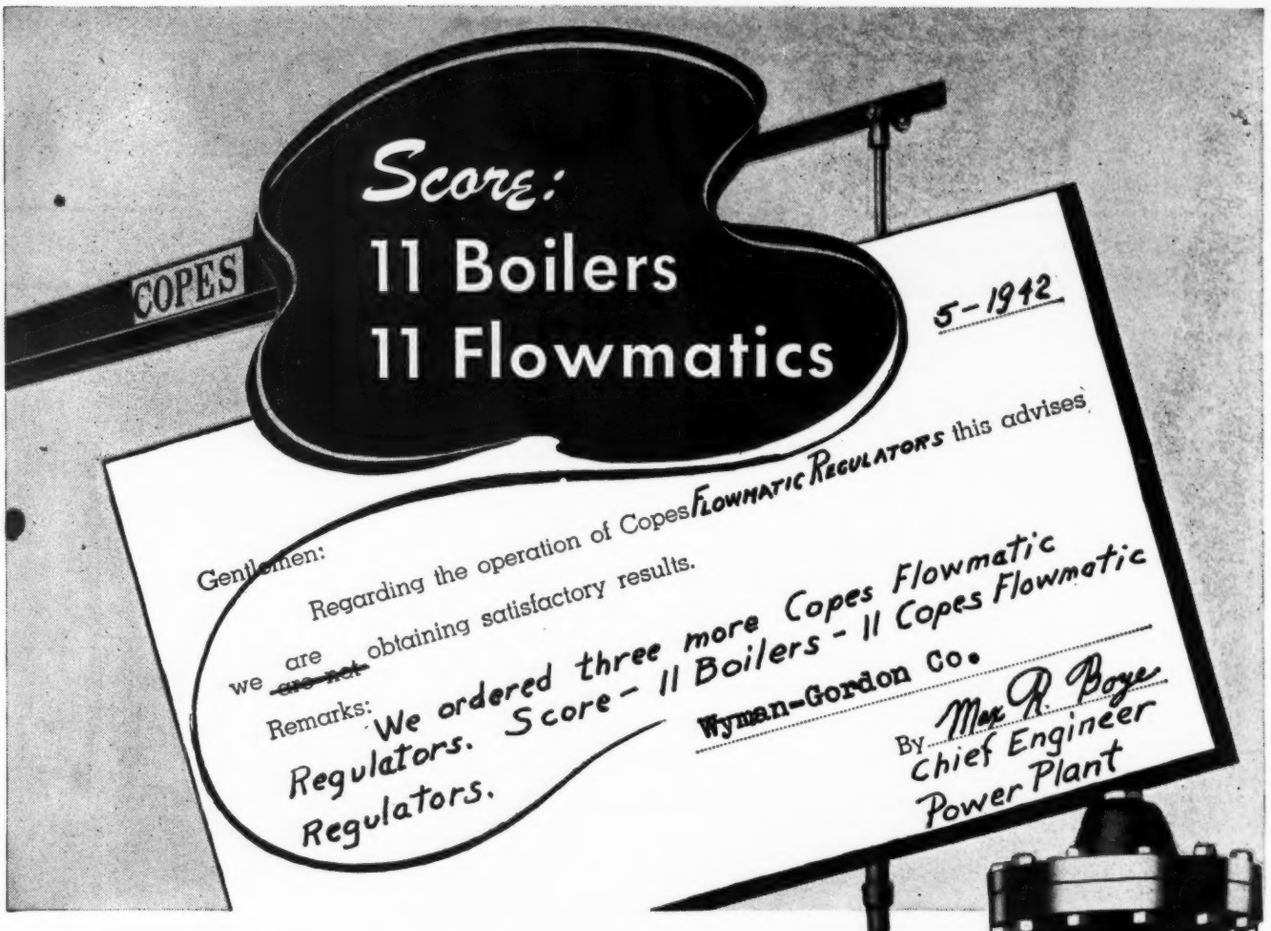

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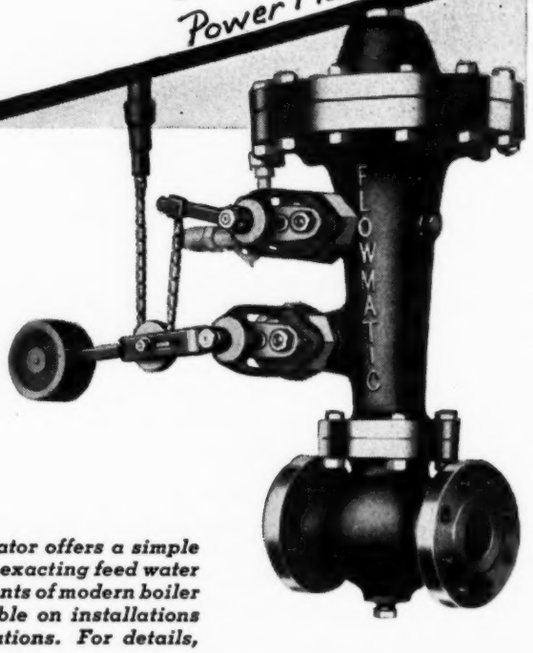

The Copes Flowmatic Regulator offers a simple reliable means of maintaining exacting feed water control geared to the requirements of modern boiler design. It is especially valuable on installations subject to severe load fluctuations. For details, write for Bulletin 429-A.

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EDITORIAL

Marysville

There begins in this issue a series of four articles dealing with the extension and modernization of the Marysville Power Plant of The Detroit Edison Company. The scope of the series includes much of the study leading to the placement of this new system capacity, the selection of unit sizes, steam conditions, method of firing, etc., as well as a detailed description, including heat balance, and a review of operating experiences to date.

It is not often that such complete accounts of an installation are published in the technical press. Space limitations ordinarily preclude it, and reader interest would probably not justify too frequent application of the idea. However, it is believed that periodically such descriptions of outstanding installations are warranted to serve as a milestone of advancing practice and as a reference for those similarly engaged in power plant design.

Seven years have passed since COMBUSTION last printed a similar series. That, it will be recalled, dealt with the modernization of the Conners Creek Power Plant of the same company. Then, as now, publication was made possible through the cooperation of the engineers of The Detroit Edison Company. The Conners Creek Series was reprinted and the large number of requests for these reprints was indicative of wide interest among designing engineers. It is anticipated that the Marysville series will meet with similar reader interest.

Another Scrap Drive

The "Victory Scrap Bank" campaign, inaugurated on October first and scheduled to continue for six weeks to the middle of November, is an effort to assist the Salvage Division of WPB in meeting its quota of fifteen million tons of iron and steel scrap from all sources during the last half of 1943.

In the first drive, conducted last year, a large tonnage of scrap of all kinds was collected from the general public, industrial establishments, power plants and utilities. That from the last two sources consisted largely of obsolete or discarded equipment and, in some cases, an excess of spare parts. Since then this reservoir has been further depleted by the necessity of reconditioning and reusing much of the remaining old equipment owing to inability to obtain new; and the present drive cannot be expected to produce a comparable amount from these sources.

Meantime, however, war production has increased several-fold and has made available large quantities of scrap from machine operations which in most cases is now being systematically segregrated and collected and serves as the main source of scrap supply. But apparently this is not proving sufficient and other sources are being asked to re-survey their possible contributions.

Output of steel, although much improved, is still short of meeting demands. This is not surprising in view of the rate of expenditure on the battle fronts, the increased naval and shipbuilding programs and lease-lend requirements. Moreover, as the tempo of warfare is stepped up on all fronts, the demand is certain to increase—hence the necessity for the present drive.

When stock is taken of the result, it is believed the power field will be found to have contributed to the limit of its present ability.

Unpredictable Trends

In times such as these most development is either the direct outgrowth of means for prosecuting the war, or results from expediencies necessitated by war conditions. Thus, in general, all wars are said to accelerate progress although the full effects in many lines may not become apparent until the period of readjustment is well along.

This can hardly be said of power plant practice, however, chiefly because the product remains unchanged, the demand during stress of war is too great to permit of normal experimentation and the personnel is taxed to the utmost. It is the aftermath of war with changed economic conditions that is most likely to have its effect on this field, tempered perhaps by experience gained in meeting certain war expediencies.

Thermally, power-plant design seems to have reached such a high state of development that little further gain in efficiency can be anticipated; hence greater attention is likely to be directed toward overall dollar economy. In this respect, a changed fuel situation is certain to be a factor in both design and operation; and economic conditions, in general, as well as improved production methods, may exert an influence toward a greater degree of standardization. Also, some substitute materials, made necessary by war conditions, will undoubtedly find a permanent place in practice, as will others that have been developed specifically for war purposes. The same applies to some methods of control, as, for instance, the application of electronics.

While post-war planning seems to be quite the order of the day in various fields, and is fully justified, there still appear to be too many uncertain economic factors in the heavy equipment industries to permit of much of a definite nature. Since the power plant field is one of service to industry, its future is interwoven with that of industry, which many believe to be headed for several years of post-war activity, particularly among consumer products. However, as yet predictions must be limited to present indications of a general character.

Addition to Capacity and Modernization of

By H. E. MACOMBER
The Detroit Edison Company

In this, the first of four articles describing in detail the extension and modernization of the Marysville Power Plant of The Detroit Edison Company, the preliminary engineering and economic studies are reviewed and high spots of the installation given. Subsequent installments will cover (1) the fuel-burning equipment, steam generators, and coal- and ash-handling; (2) the turbine-generators, heat balance and auxiliaries; and (3) piping, operating experience and list of equipment. It is believed that this very complete account will serve as an informative reference, especially for utility engineers.

SINCE 1924, practically all of the electrical energy supplied by The Detroit Edison Company has been generated by four main steam power plants. The Delray and Conners Creek plants are situated in the City of Detroit on the Detroit River; Trenton Channel, some 20 miles south of Detroit, is also on the Detroit River; and Marysville, about 55 miles north of Detroit is on the St. Clair River. A minor amount of power generated by the Company's six small hydro plants, and by non-condensing turbine-generators in the Company's central heating plants, is also fed into the system. In addition, a very small net amount may be supplied to the system as a result of interconnections with other systems, and this may be considered purchased power. In 1942 the percentage of the total power supplied from the several sources was as follows:

	Percent
From the four main power houses	98.9
From hydro and central heat generators	0.9
Purchased from others	0.2
Total	100.0

The addition to the Marysville Power House, to be described in this series of articles, was the third large-scale project involving expansion of generating facilities to be undertaken by the Company within the past ten years. The first was the rehabilitation of the entire Conners Creek Power House to a new design steam condition of 600 psi and 825 F; the second was an extension of the Delray Power House No. 3, with equipment designed for steam at 815 psi and 900 F, the first section having been placed in service in 1929, operating at 375 psi and 700 F. It superseded the old Delray Power Houses No. 1 and No. 2, both of which have since been dismantled. Both the Conners Creek and the Delray projects have been fully described in the technical press.[1,2]

Prior to the Marysville project, the nameplate ratings of the four power houses were:

	Kw
Delray:	
375 psi section	150,000
815 psi section	235,000
Conners Creek	310,000
Trenton Channel	300,000
Marysville	160,000
Total	1,155,000

Need for Additional Capacity and Choice of Location

Considerable industrial growth in the vicinity of the Northeast bulk power stepdown station, situated on the northeast boundary of the City of Detroit, brought about the need for additional generating capacity to serve that area.

Geographically this area is closer to Conners Creek and Delray than to Trenton Channel or Marysville. Delray and Conners Creek are connected to Northeast by means of 24-kv underground cables which form a part of the 24-kv system supplying the City of Detroit. These cables were already heavily loaded so that transmission of the required power from either of these power houses would have required the addition of costly transmission facilities. Because Trenton Channel serves the area generally south and west of Detroit, Northeast Station is out of its territory. On the other hand, there was in existence a 120-kv transmission line running direct from Marysville to Northeast and a second 120-kv line connecting Northeast to the 120-kv line running between Marysville and Trenton Channel.

Each of these lines carries two circuits and each follows an independent route. Under emergency conditions, when it is assumed that any two of the four circuits are out of service, it is estimated that the capacity of the remaining 120-kv circuits is of the order of 185,000 kw. In addition to the 120-kv transmission, Marysville also supplies power to its local area over 24-kv lines which are tied in with the balance of the Company's 24-kv network.

It was anticipated that the load supplied at 24 kv out of Marysville would, before very long, be of the order of 50,000 kw. Adding this to the 185,000-kw limit just mentioned, gave a total transmission capacity, under emergency conditions, of 235,000 kw. Comparing this with the nameplate rating of the plant, 160,000 kw as mentioned earlier, gave a margin in existing transmission facilities of 75,000 kw. Thus, from

[1] "Modernizing the Conners Creek Power Plant," by Sabin Crocker, COMBUSTION, Vol. 7, November 1935–June 1936.
[2] "High-Pressure Extension of the Delray Power Plant," by Max W. Benjamin, *Power Plant Engineering*, Vol. 43, February–November 1939.

...of the MARYSVILLE POWER HOUSE

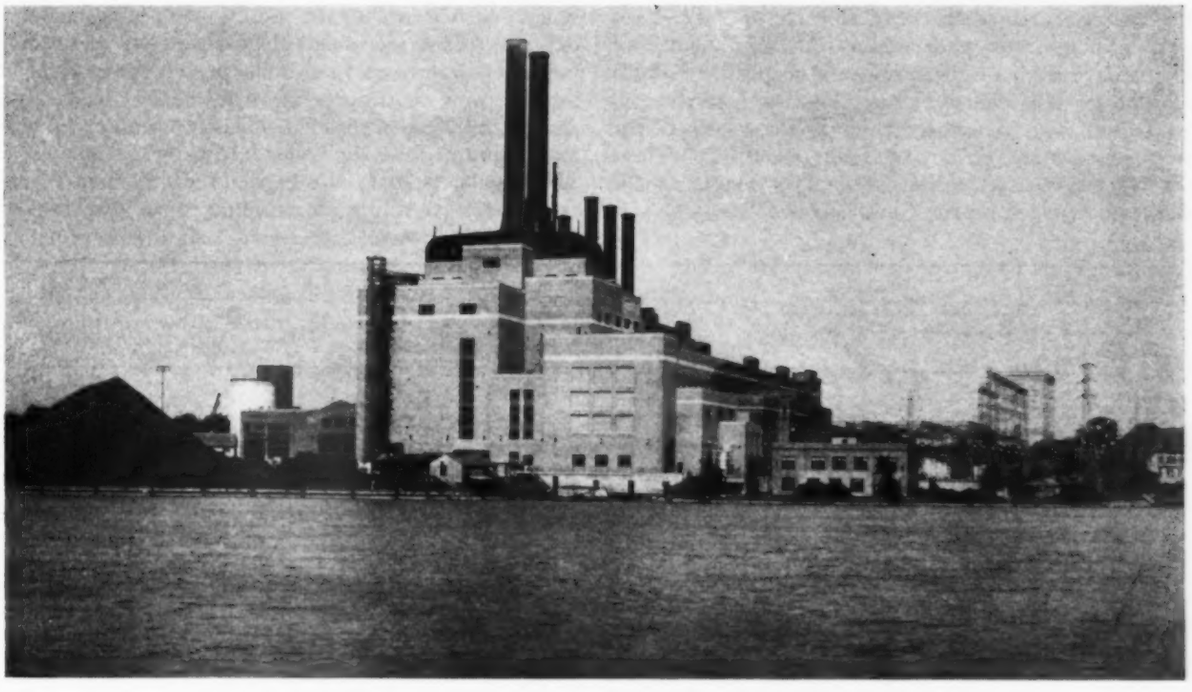


Fig. 1—Recent view of Marysville Power Plant from extension end

the standpoint of transmission, Marysville was the logical plant at which to add the needed generating capacity.

A further consideration to be taken into account was the fact that in operating its electrical system, it is the Company's practice to divide the system into several load areas so interconnected that, should an uncontrolable fault persist in any one of them, that area with its power source will disconnect itself from the system and thereby avoid a complete system shutdown. Also, each load area is, within reasonable limits, made self-sustaining.

There are five such load areas, two dependent upon Trenton Channel and one dependent upon each of the other power plants. They are connected by inter-area tie lines relayed for limited interchange of energy, yet with a capacity sufficient to provide for flexibility of operation. Normally the station load is governed by the area load and the capacity of the inter-area ties. That is, to promote overall system thermal economy, times of low system load usually find the tie lines carrying more inter-area transfer of load than times of high system load, because it is profitable to operate the more efficient equipment at a higher use factor than the less efficient equipment. In no case, however, is the running capacity of any plant less than 90 per cent of its corresponding area load.

At the time of discussion of this project, it was anticipated that the Conners Creek load area would shortly need relief. Northeast Station was at that time in the Conners Creek load area and, as indicated earlier, the 24-kv cables carrying power from Conners Creek were approaching the maximum loading. One means of providing relief to Conners Creek would be to transfer Northeast Station to the Marysville load area. With additional generating capacity at Marysville, this would be made possible. Thus, from the load area point of view also, Marysville was indicated as the desired place for the installation of the new generating capacity.

Other considerations which favored the choice of Marysville were that both Delray and Conners Creek were modern and efficient stations, and they had each been developed to an appreciable total capacity. On the other hand, Marysville was an older and less efficient plant and at the same time only about half the capacity of the other two plants.

Taking all of these factors into account, it was concluded that it would be most advantageous and most economical to install the additional generating capacity at the Marysville site.

Description of Existing Marysville Plant

The Marysville property, including a gas-manufacturing plant also operated by the Company, totals nearly 64 acres, of which the power plant property comprises about 23 acres. That part of the land on which the power plant is situated lies between a public highway and railroad right-of-way and the St. Clair River, a navigable stream for all Great Lakes shipping. When the site was purchased, a surface drainage creek, known as Bunce Creek, meandered through the property at the bottom of a ravine and emptied into the river. Nor-

mally the flowage of the creek was small but following heavy rains or a thaw, it attained a rate of around 900 cu ft per sec.

The surface stratum of the land was hard yellow clay to a depth of about 12 ft below which there was soft blue clay. Because of this condition the foundation of the power house was made in the form of a boat-type concrete mat resting on the surface of the ground without pile support. The course of the creek was straightened and the plant was so oriented that the major axis of the turbine house came directly over the creek bed. Thus, the condensing water canals running the length of the turbine house rested on the creek bed and the creek was made to flow through the outlet water canal to the river. Because of the topography of the land, it was found advantageous to fix the elevation of the boiler house operating floor fifteen feet higher than that of the turbine house operating floor.

Marysville Power House was put into service in November 1922. In a number of respects it duplicated the design features of Conners Creek which had been placed in service eight years earlier and was still the Company's most modern plant. Marysville was designed for a steam condition at the turbine throttle of 275 psi and 650 F. The initial capacity was 50,000 kw, made up of one 30,000-kw and two 10,000-kw straight condensing turbine-generators. There were four Stirling W-type boilers having double-ended underfeed stokers. Initially there were no economizers or air heaters.

Feedwater was heated in small surface-type condensers in which condensate from the main turbines was used as circulating water to condense steam exhausted from house service units. In addition to the heater-condensers, there were closed-type heaters between the boilerfeed pumps and the boilers. The purpose of these heaters was to transfer heat from the main turbine-shaft leak-off steam and the makeup water vapor from the evaporators to the boiler feedwater.

During later years the capacity of the plant was increased by extending the building in the direction away from the river and adding four more boilers, two more 30,000-kw units and finally, in 1930, a 50,000-kw unit, bringing the total plant capacity to 160,000 kw, as previously mentioned. All machines operated at the initial design steam condition of 275 psi and 650 F. In view of experience gained at Trenton Channel, which was put into service in 1924, the two additional 30,000-kw units and also the 50,000-kw unit installed at Marysville were designed for bleeding at two stages and equipped with extraction heaters.

During this period of plant extension, the older as well as the later boilers were equipped with economizers and larger induced-draft fans. Also, the last boiler (No. 8), which was added at the time the 50,000-kw

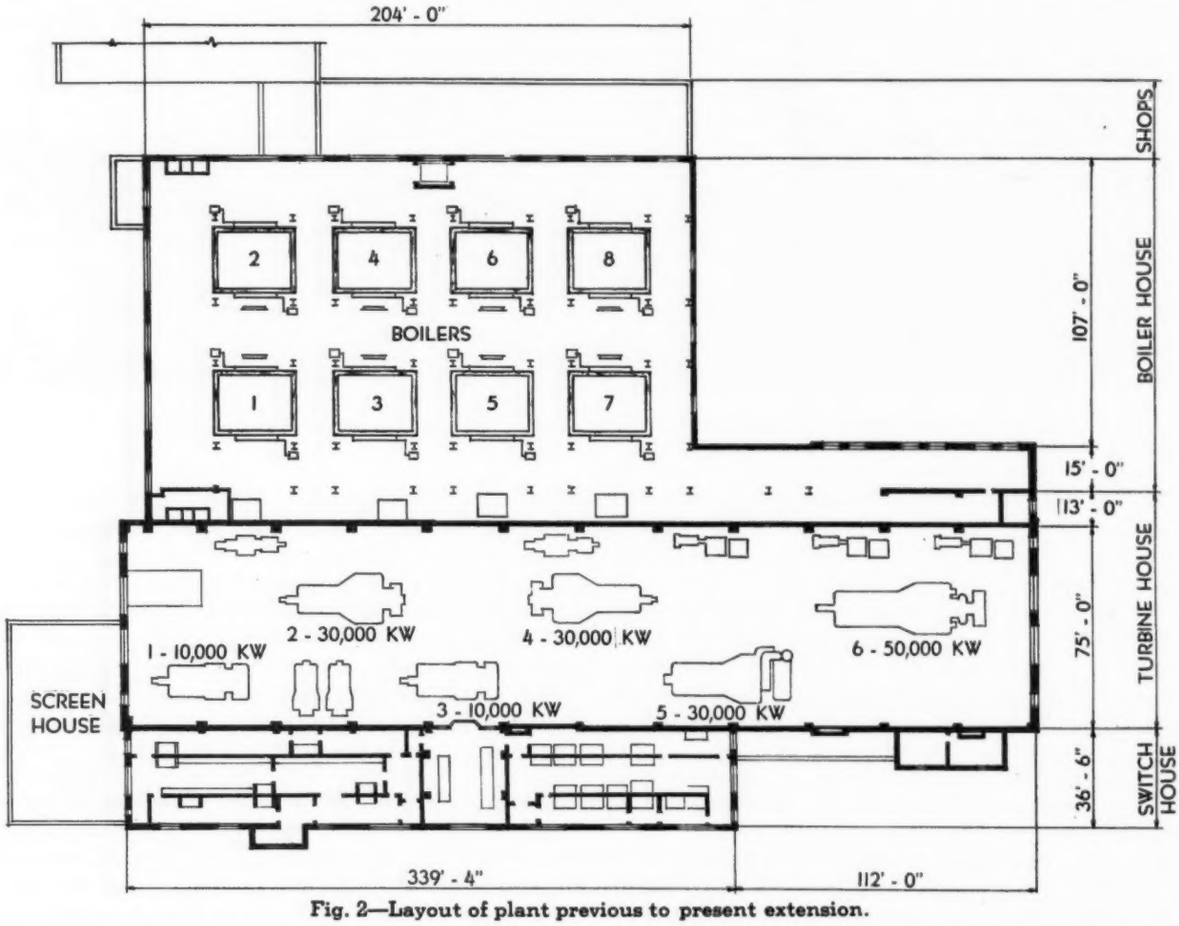


Fig. 2—Layout of plant previous to present extension.

unit was installed, was equipped with water walls. In addition to improving the thermal performance of the plant, these additions also precluded the need for an additional boiler which otherwise would probably have been required to serve the total installed turbine-generator capacity.

Fig. 2 shows the floor layout and location of turbines and boilers in the old plant. An extension of the boiler house mat at the end farthest from the river had been provided for the possible future addition of two more boilers.

The boiler column spacing was 29 ft in width and 31 ft in depth, front to rear, at column centers. There were 15-ft transverse aisles between boilers and a 23-ft longitudinal aisle running the length of the house with boilers on each side. Each boiler was equipped with an individual self-supporting steel stack, the top of which was 175 ft above the operating floor.

The turbine house was laid out to accommodate the turbine-generators with their longitudinal axes lengthwise of the room. This arrangement permitted a house of 75 ft in width, and 336 ft in length. The height of the boiler house from basement floor to roof was about 107 ft, and that of the turbine house 85 ft.

When Marysville Power House was first put into service, it had a heat rate of the order of 16,500 Btu per net kilowatt-hour. However, the later addition of heat recovery equipment and the addition of the two 30,000-kw and the 50,000-kw turbine-generators, operating on the regenerative cycle, reduced the heat rate for the station as a whole to about 14,000 Btu per net kilowatt-hour, which it maintained for a number of years.

Selection of Method for Increasing Plant Capacity

An increase in the generating capacity at an existing plant site can, in general, be accomplished in one of at least five different ways, namely:

1. Build a new power house of the required capacity. (This procedure was followed in the case of the initial section of Delray Power House No. 3.)
2. Extend the existing plant with new equipment designed to operate at the existing steam conditions. (This method was followed in extending Trenton Channel.)

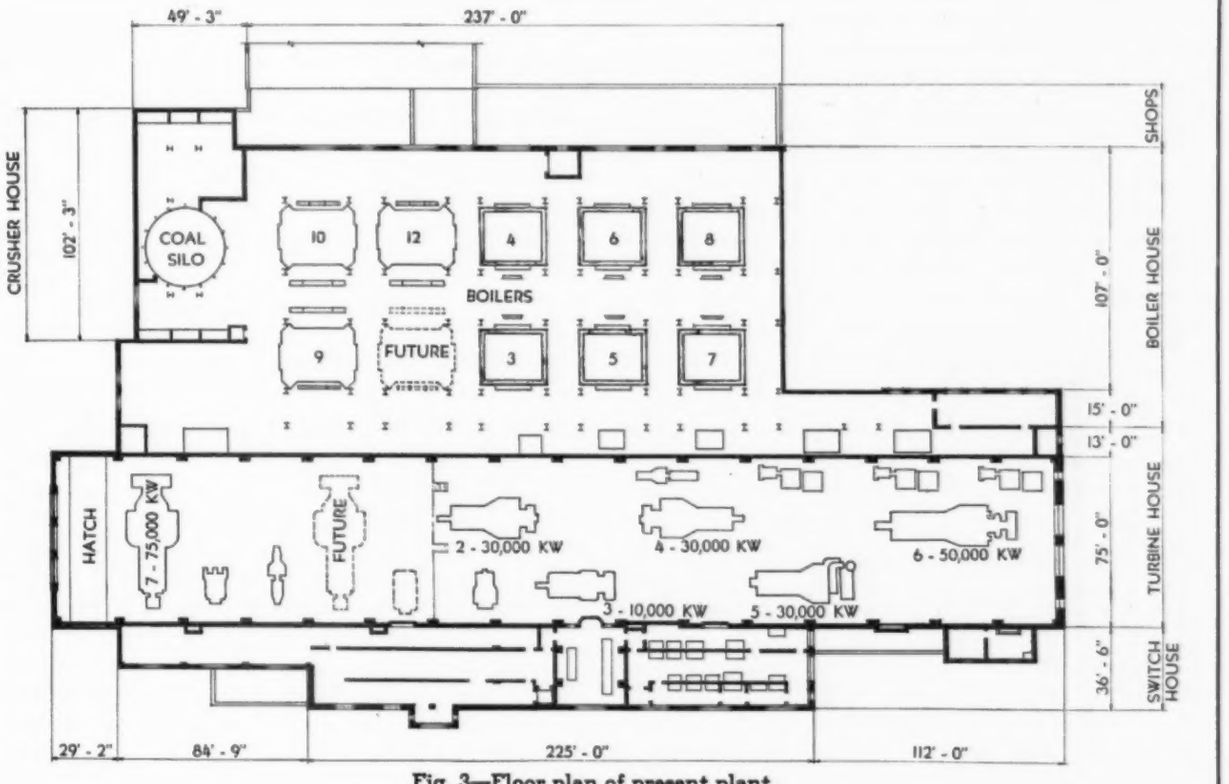


Fig. 3—Floor plan of present plant

3. Extend the existing plant with new equipment designed to operate at higher steam pressure and temperature than the existing plant. (This method was followed in extending Delray Power House No. 3.)
4. Rebuild the existing plant by replacing the equipment with larger capacity and more efficient equipment. (This method was followed in the case of Conners Creek.)
5. Superpose upon the existing plant, higher pressure boilers and turbines which would exhaust to existing low-pressure turbines.

It is interesting to note that of these five methods, The Detroit Edison Company has adopted four in different instances. The one procedure not adopted thus far in any major project is, oddly enough, that of superposition which has been very popular in the industry.

It is recognized that superposition results in increased thermal economy as well as increased generating capacity. Both factors, however, are limited by the existing steam conditions and the capacity of the existing turbines. An important factor where superposition is being considered as a means of increasing capacity is the thermal economy of the old equipment in its present form and also its suitability for use during system peak loads. Among other considerations are the degree of obsolescence, the physical condition, reliability, and convenience of operation of the old generating equipment which, with new equipment superposed upon it, is committed to continued service for an extended period. Likewise, careful consideration must be given to the serviceability and probable remaining life of the existing boilers which would be supplanted by the new high-pressure boilers.

In selecting a method for increasing the capacity at a given plant site it is obvious that consideration should be given to possible future requirements beyond immediate needs so that the first steps taken will fit into a logical plan for further development should that prove desirable.

In the case of Marysville there was nothing in the picture to suggest the wisdom of starting a new plant, and to extend the old plant with new equipment designed to operate at existing steam conditions was, of course, not feasible. Studies of the possibilities of superposition showed that this method was neither practicable nor economical as a means for accomplishing the immediate or any future aim at Marysville.

As to replacing existing equipment with new and modern equipment of larger capacity, the good thermal performance of the old plant, despite its outmoded steam conditions, made it difficult to justify retirement of any major part of the old equipment, at least for some time to come.

Factors Governing Plant Extension

The method finally adopted for the first step, therefore, was the extension of the plant toward the river and the installation of new equipment. Plans were worked out in such a way as to provide space for a 75,000-kw condensing unit and three new boilers with the removal of but one old boiler (No. 2). The chief advantage of extending the plant on the river end was that the oldest equipment, and that which it was most logical to retire first, was located in that end of the building. Other advantages in building the extension on the river end were that the new turbine-generator would be closer to the source of circulating water, the new boilers would be better situated with respect to both the new and existing turbine-generators and, further, this scheme permitted a better arrangement and location for the new coal-handling system. The installation of a pressure and temperature reducing station, so that steam could be supplied from the new boilers to the existing turbines to compensate for the removal of low-pressure steam-generating equipment, was also made a part of the first step.

As a second step to be carried out when conditions warranted, the plan called for the installation of a second 75,000-kw unit and a fourth new boiler. Space for this equipment was to be provided by the removal of one of the old 10,000-kw turbine-generators and a second old boiler (No. 1).

Looking to the more distant future when retirement of all of the old equipment might be justified, the projected plan called for the installation of a third and a fourth 75,000-kw turbine-generator with accompanying new boilers and the removal of all old equipment except the 50,000-kw unit which would then be operated with steam passed through the pressure- and temperature-reducing station or possibly through a topping turbine.

It should be understood that beyond the first two steps the plan is in no way a definite commitment. Details were worked out merely to give assurance that the first steps in the program would form part of a logical plan for future development should such later development become desirable. What will be done in the future is left entirely flexible, the final course to be settled upon at such time as a definite decision may become necessary.

Turbine-Generator Unit Size and Initial Steam Condition

When making additions to the generating capacity of the system, it is the general practice of The Detroit Edison Company to adhere to a particular size and type of turbine-generator until there is sufficient reason for changing to a larger size. With this procedure, duplicate machines, except for minor variations to suit differences in steam conditions and feed-heating arrangements, may be installed in different power houses as the needs for additional capacity arise at those locations. As witness to this practice, there are now in operation on the system, ten 50,000-kw units; six at Trenton Channel, three at Delray and the one at Marysville. The next size as a series is 60,000 kw, there being three in operation at Conners Creek. Following this, there was a change to the 75,000-kw size in the installation of the three latest units at Delray.

There are a number of benefits which accrue from the duplication of machines on the system. For obvious reasons it simplifies operating and maintenance procedures and also makes for economy of investment in spare parts. As an example of the advantages of interchangeability of parts, the Company has on hand a spare turbine rotor which can be installed in any of the ten 50,000-kw machines on the system and another is available for the three 60,000-kw units at Conners Creek. A third spare turbine rotor for the 75,000-kw machines is now on order. A spare turbine rotor can shorten the time of shutdown greatly when major repairs to an operating rotor are required.

In the rebuilding of the Conners Creek Plant in 1933 there was a deviation from this practice in that three 30,000-kw units were selected after several 50,000-kw machines had been installed on the system. The explanation for this is that it was found profitable to continue the use of existing 30,000-kw generators and parts of existing low-pressure 20,000-kw and 30,000-kw turbines to build new 30,000-kw turbine-generators designed to operate at 600 psi and 825 F.

In the early consideration of the Marysville project there were certain circumstances pointing to a 60,000-kw unit as appropriate for increasing the capacity. Among these were the amount of load to be picked up, the comparatively remote location of the plant, and the fact that the Marysville area load was not very large at the time and was not expected to develop at an accelerated

rate. Further study, however, indicated that the 75,000-kw size would be preferable and also it was found that in succeeding steps of the projected development ample boiler capacity could be provided for units of the larger size within the existing column spacings in the old boiler house. Because of these conditions and the fact that there were already three 75,000-kw units on the system the final decision was in favor of that size for installation at Marysville.

The design steam condition of 815 psi and 900 F at the turbine throttle selected for Marysville duplicates that employed for the high-pressure section at Delray. In the case of Delray, it was chosen after an analysis based upon the known results of Conners Creek operation at 600 psi and 825 F and after studies of predicted performance at other conditions, namely at 815 psi and 900 F, and 1200 psi and 950 F.

In such a study, the initial steam temperature is, of course, pretty well limited to 900 to 950 F by the materials available for the fabrication of equipment to be exposed to such temperatures during operation at the design pressure. A considerable amount of information of this subject was accumulated by the Company[3] as the result of operating experience since 1929, with an 1100 F experimental superheater at Trenton Channel and a 1000 F, 10,000-kw turbine-generator and separately fired superheater at Delray. The pressure in both instances was the existing station pressure of about 380 psi.

As for pressure, the study undertaken for the Delray extension indicated that with loading conditions continuing on the system as in the past, the gain in thermal economy for an advance in initial steam conditions from 815 psi and 900 F to 1200 psi and 950 F would not justify the additional investment required to provide equipment for 1200-psi service. In each instance the comparisons were made for straight regenerative cycles without reheat.

Review of the Delray studies in the light of operating experience, and investigation of current prices for higher pressure and temperature equipment, showed that the conclusions reached in the case of Delray were still sound and equally applicable to the Marysville project. It is well to note further in this connection that it is not the practice of the Company to base-load the most efficient or newest plant; rather such a plant is given a preferential load. With preferential loading, the most efficient plant will carry a higher percentage of the total load on the system than the less efficient plant; however, its load will vary with the load on the system as dictated by the load in its own area and the load on the inter-area tie lines.

Based on long-time experience with this type of loading, it is the Company's practice in design calculations to use a figure of 45 per cent as the over-all life plant-use factor. This figure is probably lower than

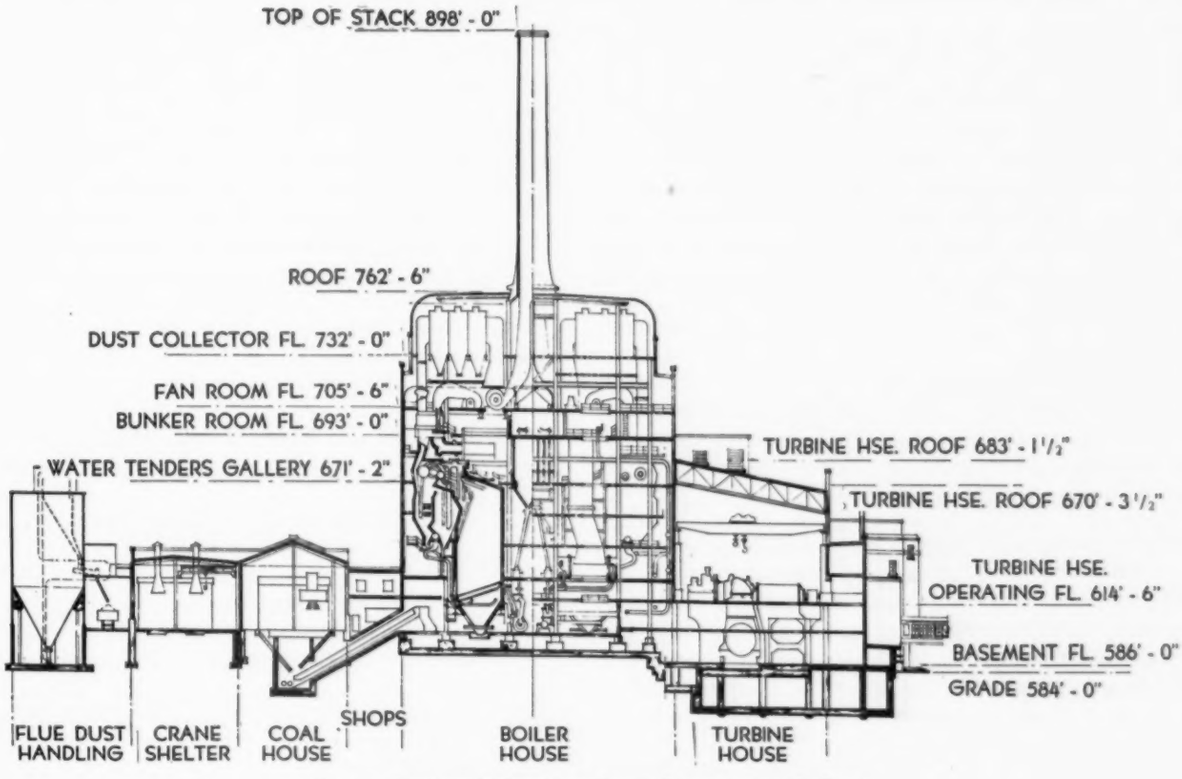

TOP OF STACK 898' - 0"
ROOF 762' - 6"
DUST COLLECTOR FL. 732' - 0"
FAN ROOM FL. 705' - 6"
BUNKER ROOM FL. 693' - 0"
WATER TENDERS GALLERY 671' - 2"
TURBINE HSE. ROOF 683' - 1 1/2"
TURBINE HSE. ROOF 670' - 3 1/2"
TURBINE HSE. OPERATING FL. 614' - 6"
BASEMENT FL. 586' - 0"
GRADE 584' - 0"
FLUE DUST HANDLING
CRANE SHELTER
COAL HOUSE
SHOPS
BOILER HOUSE
TURBINE HOUSE

Fig. 4—Sectional elevation through new part of plant

[3] "High-Temperature-Steam Experience at Detroit," by P. W. Thompson and R. M. Van Duzer, *A.S.M.E. Transactions*, Vol. 56, 1934, page 497; "Thermal Performance of the Detroit Turbine Using Steam at 1000 F," by W. A. Carter and F. O. Ellenwood, *A.S.M.E. Transactions*, Vol. 56, 1934, page 477; and "High-Temperature-Steam Experience at Detroit," by R. M. Van Duzer and Arthur McCutchan, *A.S.M.E. Transactions*, Vol. 61, 1939, page 383.

that used by others who find it possible to justify plants built for operation at higher pressures and temperatures than those thus far adopted by The Detroit Edison Company.

Description of Extension

Fig. 3 shows the operating floor plan layout as finally adopted, and Fig. 4 is a sectional elevation of the extension. Comparing Figs. 3 and 2 it will be seen that turbine-generator No. 7 and new boilers No. 9 and No. 10 occupy the new extension to the building, whereas boiler No. 12 occupies the place of old boiler No. 2. Fig. 3 also indicates future turbine-generator No. 8, the second 75,000-kw unit to be installed later in the place of old No. 1, a 10,000-kw unit, and future boiler No. 11 to be installed in place of old boiler No. 1. These future installations represent the second step of the project.

In the original plant (Fig. 2) it is seen that the condensing water screens and house abutted on the river end of the turbine house and extended a distance of 46 ft. In extending the turbine house, it was lengthened by four bays, or 113 ft, the last or end bay serving for access to the turbine house crane for material transported by railroad or truck. The screens and wells were moved toward the river a distance of 40 ft in order to accommodate the connection and supply of condensing water to the condenser pump for the new No. 7 unit. Consequently, all the screens and screen wells are now within the turbine house.

Finally, it will be noted that with an 84-ft extension at the river end of the turbine house, exclusive of the access bay for entrance of railroad cars or trucks, it has been possible to provide space for two 75,000-kw units with the removal of but one of the old 10,000-kw machines.

The turbine house operating floor level in the extension is 5 ft above the level of the operating floor in the old turbine house. The additional distance between the basement and operating floors was required to provide head room for extraction heaters and piping associated with the new units. In the boiler house extension the operating- and basement-floor levels were made to agree with the corresponding floor levels in the old plant.

The design of the new steam generators is such that one self-supporting steel stack serves a battery of two units located on opposite sides of the firing aisle. The stacks are 14 ft $5^1/_2$ in. inside diameter at the boiler-room roof line, and 13 ft $5^7/_8$ in. inside diameter at the top. The height is 273 ft. 6 in. above the operating floor and 300 ft above grade. The principal reason for what may seem to be excessive height is to effect the widest possible dispersal of any flue dust that may get past the collectors and thus be discharged to atmosphere with the flue gases.

In addition to the main boiler house extension just described, a further extension of the main building was built to house coal storage and handling facilities for both the new and old steam generators. This extension, shown in Fig. 3, is 48 ft long and houses a 2000-ton coal-storage silo, the crushers and elevating conveyors.

Aside from the main building extensions are the structures erected separately to house equipment for the handling and storage of ash removed from the bottoms of the new furnaces and dust caught by the flue-dust collectors. A detailed description of this part of the project will follow in a later installment.

Construction Field Schedule

Preliminary field work for the substructure of the building extension was started early in the spring of 1941 and the first steam generator was placed in initial operation in September 1942, with steam discharged through the reducing station to the low-pressure system. This date preceded by seven months the availability of turbine-generator No. 7, the manufacture of which had been unavoidably delayed. The second steam generator was ready for operation in December 1942 and the third was completed in August 1943.

In the spring of 1942 there developed a projected need for a considerable amount of additional power in the immediate Marysville area. To meet this need, work was started at once on the second step of the project involving the installation of the second 75,000-kw turbine-generator and the fourth high-pressure steam generator. The completion date for this second step was tentatively set for late 1943. In preparation for the installation of this new equipment, the 10,000-kw turbine-generator No. 1 and old boiler No. 1 were removed. About this time, however, changes in considerations which had prompted the undertaking of the second step resulted in the cancellation of that part of the project by the War Production Board. As a consequence, the completion of the first step leaves the nameplate capacity of the plant less by 10,000 kw than was originally intended; that is, the net increase in capacity at the completion of the first step is 65,000 kw instead of 75,000 kw, making the present total plant capacity 225,000 kw.

Main and Auxiliary Electrical Systems

Main Electrical System

The electrical energy generated at Marysville is delivered to the electrical system at two main bus voltages, namely: 120 kv to the bulk power system, and 24 kv to the local area.

In the original Marysville Plant, the 24-kv bus and switches were located inside the power house building. Somewhat later, in accord with subsequent Company practice, and in order to provide additional generator and distribution-feeder positions, the 24-kv bus was "extended" as an outdoor structure located about $^1/_8$ mile from the power house. This extension, which now provides the major 24-kv bus and switching facilities of the plant, is known as "Bunce Creek Station." The bus at this station is tied to the indoor 24-kv bus in the power house by three 750,000-cir mil single-conductor cables carried underground. These two 24-kv busses are normally considered as one. Generator leads and ties between the power house, the 120-kv bus and the 24-kv bus at Bunce Creek are also carried underground.

Before the addition of the generating capacity with which this article is concerned, the generator connections were as shown in Fig. 5 with the 30,000-kw units, No. 2 and No. 4, and the 50,000-kw unit, No. 6, connected to the 120-kv bus, and the 10,000-kw units, No. 1 and No. 3, connected to the 24-kv bus. The remaining 30,000-kw unit, No. 5, was arranged for throw-over to

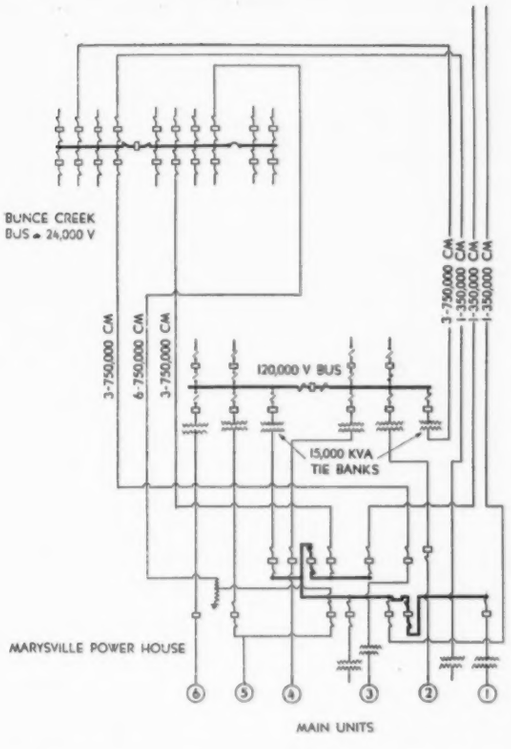


Fig. 5—Generator and bus connections of the old plant

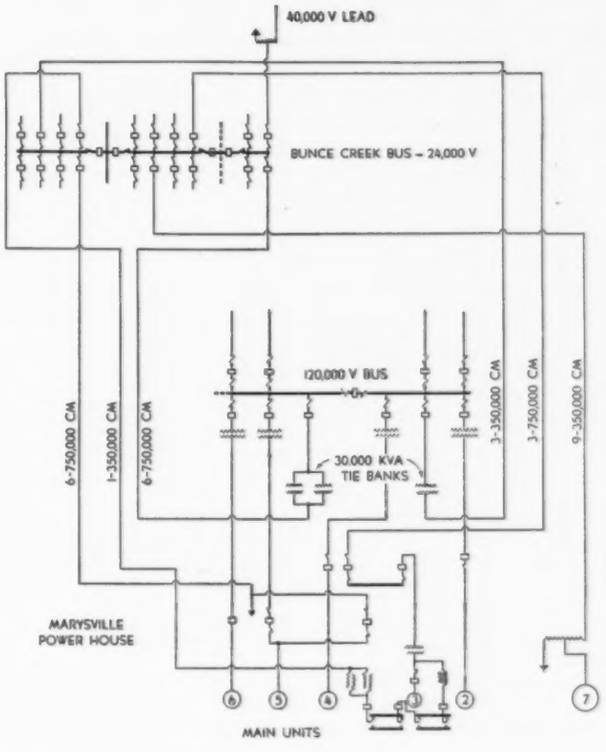


Fig. 6—Generator and bus connections of the present plant

either bus. In addition, there were two 15,000-kva tie-bank load ratio control transformers for interchange of energy from one bus to the other.

Thus, with No. 5 unit connected to the 24-kv bus, there were 50,000 kw of generating capacity, 30,000 kva of tie-bank and tie-line capacity, and a small amount of capacity from the 24-kv network which gave a total of approximately 85,000 kw available for the local 24-kv load area.

According to Company practice, the firm capacity of a load area is considered as the sum of the rated capacities of all generators supplying the area, plus tie-bank and tie-line capacity, minus the capacity of the two largest supply units within the area. The basis for this practice is the assumption that the maximum probable loss of available generating capacity is represented by the emergency shutdown of one of the two largest units at the time when the other of the two largest units is out of service for scheduled inspection and overhaul. In the case of the Marysville 24-kv load area, the firm capacity, according to the above definition, was 40,000 kw. The growth of the 24-kv load in the area had been such that by December 1941 it closely approached this firm rating. Therefore, in addition to increasing the capacity of the Marysville Plant as a whole, it was also desired to increase the firm capacity of the 24-kv section.

This was accomplished by connecting the new 75,000-kw turbine-generator to the 24-kv bus and by paralleling the two existing 15,000-kva tie banks to form one 30,000-kva bank, also installing a new 30,000-kva transformer to serve as a second tie-bank. By these means, the firm capacity of the local 24-kv area was increased to 70,000 kw. The resulting arrangement of the main bus layout is shown in Fig. 6.

The new 75,000-kw turbine-generator is connected to the 24-kv bus at Bunce Creek Station by nine 350,000-cir mil three-conductor cables in a separate duct run. There is no breaker between the generator and its auto-transformer and, in order to permit synchronizing the generator, the control of the breaker between the auto-transformer and the bus at Bunce Creek is carried back to the power house switchboard.

Auxiliary Electrical System

In revamping the electrical system used for the operation and control of the power-house auxiliaries, maximum advantage was taken of the existing equipment such as motors, busses, switches, and auxiliary generating equipment.

In the original Marysville Plant, direct current was used for driving all auxiliaries essential to continued operation of the plant. Included in this category were the boiler-feed pumps, condensate pumps, condensing and house-service water pumps, stoker motors, boiler draft fans, etc. Other auxiliaries, classed as semi-essential, were driven by a-c motors. Semi-essential auxiliaries include equipment which can be taken out of service for a period without jeopardizing the continuity of plant generation.

In selecting the drives to be used for the auxiliaries required in the first and succeeding steps of this project, a-c motor drives were chosen for some of the essential auxiliaries, chief among which were the motor-driven boiler-feed pumps and the coal pulverizers. In the case of the former, the operating speed requirement of a high-pressure boiler-feed pump practically precludes the use of a direct current motor because of commutator difficulties. As to the latter, the pulverizer is a constant-

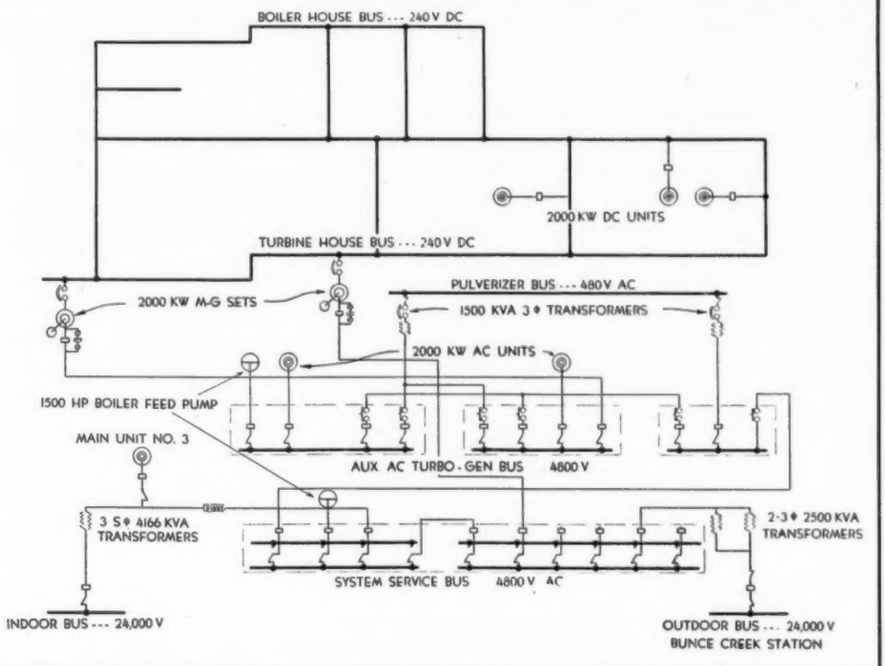

BOILER HOUSE BUS --- 240 V DC
2000 KW DC UNITS
TURBINE HOUSE BUS --- 240 V DC
PULVERIZER BUS --- 480 V AC
2000 KW M-G SETS
1500 KVA 3 ϕ TRANSFORMERS
2000 KW AC UNITS
1500 HP BOILER FEED PUMP
MAIN UNIT NO. 3
AUX AC TURBO-GEN BUS 4800 V
3 S ϕ 4166 KVA TRANSFORMERS
2-3 ϕ 2500 KVA TRANSFORMERS
SYSTEM SERVICE BUS 4800 V AC
INDOOR BUS --- 24,000 V
OUTDOOR BUS --- 24,000 V
BUNCE CREEK STATION

Fig. 7—Auxiliary electrical system diagram

speed device and, with a firm supply of a-c energy available, it followed logically that a-c drive would be the most economical.

The auxiliary electrical system now provided at Marysville, as shown schematically in Fig. 7, is divided into four principal parts as follows:

1. A 4800-volt system-service bus supplied primarily through two transformer ties, one from Bunce Creek and one from the 24-kv bus in the power house.
2. A 4800-volt auxiliary a-c turbine-generator bus supplied by two 2000-kw auxiliary a-c turbine-generators and by a tie to the system-service bus.
3. A 480-volt pulverizer bus supplied through transformers from the auxiliary a-c turbine-generator bus.
4. A 240-volt d-c ring bus supplied by three 2000-kw auxiliary d-c turbine-generators and two 2000-kw motor-generators.

In addition to the four bus systems mentioned, there are:

a. A 230-volt a-c auxiliary house-service bus supplied through transformers from the system-service bus, and

b. A transformer on the 75,000-kw turbine-generator. This transformer supplies the energy to operate three of the four generator ventilating fans, the heater drains pump, and one condenser pump associated with the turbine-generator. Energy for the fourth ventilating fan motor is supplied from the 230-volt a-c house-service bus.

It is important to note that the system-service bus and the 230-volt a-c house-service bus are the only parts of the auxiliary system normally supplied directly from ties to the main electrical system. An additional feed to the system-service bus aside from that through the system-service transformers can be provided from No. 3, 10,000-kw turbine-generator. That is, as long as this unit is operated, power through this feed to the system-service bus can be supplied either from Bunce Creek Station or directly from No. 3 unit. Thus, with this arrangement, the system-service bus has a source of supply from within the power house; a precaution which for the present is of value, in view of the fact that until the second 75,000-kw unit is installed only one turbine-driven boiler-feed pump is held in reserve. Later, in the event of removal of No. 3 turbine-generator, the system-service bus will be dependent entirely upon service from Bunce Creek. At that time, however, the second and third 75,000-kw units would be in service, each accompanied by an additional reserve turbine-driven boiler-feed pump.

In the meantime, the two existing 2000-kw auxiliary a-c turbine-generators will be available, although only one will be rated as a preferred source of power. The reason for this is that, until such time as the third 75,000-kw turbine-generator is installed only one of the above auxiliary units will be moved to a new location in the rebuilt plant and equipped with a river-water condenser, while the second will continue to serve as a heat-balance unit for the low-pressure main turbines which are not equipped with extraction heaters.

The two existing 2000-kw motor-generator sets will continue to be operated to transfer energy to the 240-volt d-c bus. One motor-generator is supplied from the auxiliary a-c turbine-generator bus, the other from the system-service bus. The first is considered a firm source of power for the d-c bus when either of the a-c auxiliary turbine-generators is operated, but the second motor-generator set cannot be considered a firm source unless No. 3 main turbine-generator is in service.

The load on the auxiliary system and the firm capacity

necessary to safeguard the continuity of sufficient auxiliary power is, of course, a function of the main turbine-generator capacity available at any time in the plant.

In establishing the firm capacity of the auxiliary system, two underlying assumptions were made:

1. That no auxiliary turbine-generators or motor-generators would be scheduled for repair outage except during the scheduled outage period of a main turbine-generator. The given capacity under this assumption, therefore, would be represented by the loss of only one auxiliary generator.

2. That loss of Bunce Creek as a source of auxiliary power would be the result of the complete loss of that station from the system. Under these circumstances there would be a drop in the demand on the main turbine-generators and accordingly a reduction in the auxiliary power demand.

The rated capacity of the auxiliary system and the estimated maximum essential auxiliary power demand involved in the first step of the Marysville project is as follows:

Auxiliary System Rated Capacity, Kw

	Normal	Emergency*
Firm Capacity		
Direct current	8000	6000
Alternating current	2000	2000
Available Capacity		
Direct current	8000	6000
Alternating current	2000	2000
Direct current or alternating current	2000	2000

Estimated Maximum Essential Auxiliary Power Demand, Kw

	Normal	Emergency*
Plant Rated Load		
Direct current	5970	4450
Alternating current	1710	880
Plant Overload		
Direct current	6420	4480
Alternating current	1750	1320

* Service from Bunce Creek Station interrupted.

Aside from providing sufficient (back-up) generators and transformers to carry the load on the auxiliary system in case of loss of any one of them, or during repair periods, the following additional provisions have been incorporated in order to insure stability of the system in case of electrical faults without and within the auxiliary electrical system.

1. The relaying of the circuit breaker in the single tie between the auxiliary a-c turbine-generator bus and the system service bus (Fig. 7) is set for trip-out in about 15 cycles in case of system faults to insure stability of the auxiliary system under the worst conditions. This breaker is also relayed for trip-out in about 60 cycles in case of a power-flow of 500 kw from the auxiliary a-c turbine-generator bus to the system-service bus. Both sets of relays are made inoperative in the event that neither auxiliary a-c turbine-generator is available.

2. The relaying on all breakers feeding loads from the auxiliary a-c turbine-generator bus is instantaneous for high-current faults. In addition, 35 to 45 cycle back-up relaying is provided on the section breakers.

3. The 480-volt transformer secondary breakers each consists of three single-phase breakers with multi-contact relays and independent control circuits. Both differential and directional relays are provided. The 4800-volt, 480-volt and direct-current systems are ungrounded, whereas the 230-volt a-c system is grounded through grounding transformers.

It is thus seen in the design of the auxiliary electrical system, in so far as the essential services are concerned, that the aim is to safeguard continuity of service irrespective of disturbances on the main system. This is provided, of course, by making steam-driven auxiliaries available as standbys in some instances, although principally under all normal circumstances the continued supply of auxiliary energy is a function of the auxiliary generators backing up the feed of auxiliary energy supplied from the main system through the system-service bus.

Ordinarily, the transfer of energy from the main electrical system to the auxiliary system through the system-service bus will care for the so-called non-essential services and, in addition, a considerable proportion of the load on the auxiliary a-c turbine-generator bus. The reason is that the heat-rate cost of main-system energy is less than the cost of auxiliary generation. At all times, however, the auxiliary generator spinning reserve is held sufficient to take over in the case of system faults that might result in separation of the main and auxiliary electrical systems.

Facts and Figures

The National Grid in Great Britain is at present being supplied by 140 selected power stations.

●

According to WPB estimates, a ten per cent reduction in domestic and commercial use of coal for heating would save over twenty million tons annually.

●

The two-thousandth ocean-going vessel built under Maritime Commission contract since Pearl Harbor was delivered ready for service on September 11.

●

The average life of boilers in the Lancashire cotton mills in England is reported as 40 years.

●

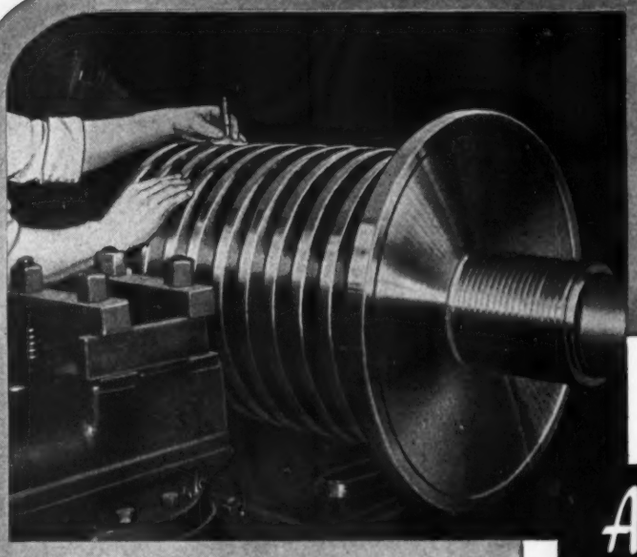
Long before the advent of reheat as applied to turbine installations, it was the practice to employ this principle to jacketed receivers of multiple-expansion reciprocating engines.

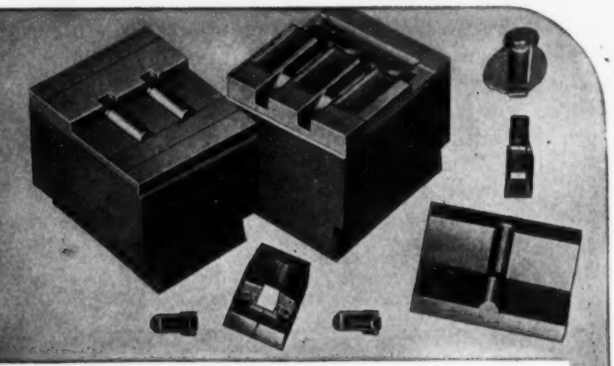
●

In the 1942–43 Safety Contest, sponsored by the National Safety Council, 15 of the 191 participating utilities went through the twelve-month period without a single reportable injury.

●

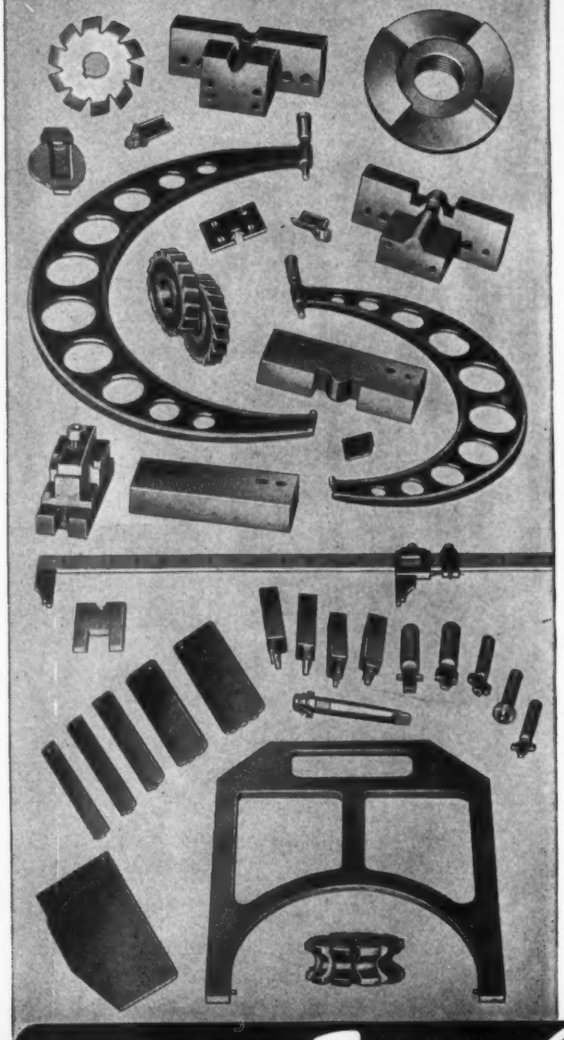
Electricity produced for public use during the month of August 1943 reached an all-time high of 18,945,144,000 kw hr which represented an increase of 18.3 per cent over that produced in August 1942. The average daily production also represented a new high level.





Special tools, gages, jigs and templates used in the production of the integral steam turbine rotor shown.

A Manufacturing Policy THAT HAS STOOD THE TEST OF TIME



From its inception in 1901, the De Laval Steam Turbine Company has recognized that the best results are obtainable only by confining the work of its staff to the development, design and production of a single class of manufacture, having the same general characteristics and requiring the same processes and high grade of workmanship. Consequently the efforts of the company have been confined to high-speed rotary power equipment, including STEAM TURBINES, HELICAL and WORM SPEED REDUCING GEARS, CENTRIFUGAL PUMPS and COMPRESSORS and ROTARY OIL PUMPS.

The jigs, tools and gages required for the production of high-grade work are much more expensive and elaborate than are those necessary for work requiring less refinement and care in manufacture. Also, the type of shop employee who can perform this accurate work is entirely different from that required for less particular and accurate classes of work.

M-29

De Laval STEAM TURBINE CO.
TRENTON 2, N.J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC; PUMPS . . . CENTRIFUGAL, CLOGLESS, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, PROPELLER; PRIMING SYSTEMS; CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS . . . WORM, HELICAL, and FLEXIBLE COUPLINGS

Chemical De-scaling of Boilers and Power Plant Equipment

The basis of chemical de-scaling, employing different inhibitors, is explained; its scope and advantages defined; the method of application described; and results of its use in removing mill and welding scale from the tubes of a new forced-circulation boiler are given in detail.

By M. M. De WITT

Development Engineer, Dowell, Inc.

REMOVAL of scale from internal surfaces of heat-exchange equipment presents one of the major problems of plant operation. Mechanical methods of removal have not always been entirely satisfactory due to required shutdown periods, increased cost of labor, and in some cases incomplete scale removal. During recent years, chemical removal has made steady progress because of the development of more effective inhibitors, various additive agents and improved treating technique.

In this discussion the term "Scale" will be rather loosely employed. Scale, in its true sense, usually is considered as dense tenacious formation, while "deposits" cover the more loosely laid down sediments and softer sludge. For this discussion "scale" is considered as meaning any and all scale and deposits in heat-exchange equipment.

The base of most solvents used in scale-removal treatments is inhibited hydrochloric acid. To this are usually added agents which have been found to greatly increase the solubility and facilitate the removal of silicates, phosphates, iron oxides and other compounds commonly found in scales. The correct type and amount to use are determined by an analysis of the scale. Removal of scale from metal surfaces by the use of acid is an old procedure but was not an accepted practice until recent years, due to excessive metal corrosion. Its recent growth is due to the development of effective inhibitors which limit metal corrosion but do not materially reduce scale reaction.

There are numerous substances that possess inhibiting qualities in various degrees including aldehydes, glue, dextrine, glucose, crude anthracene, anthracene residues, waste sulphite lyes, coal-tar products, thiourea, quinoline, pyridine and many others. Later discoveries have added to the list several new inhibitors with hitherto unrealized potency. The proper inhibitor is selected after careful consideration has been given to the required treating temperatures, metals in the vessel to be treated and service to which the vessel is put. The selection of the proper inhibitor is as important as the selection of the proper solvent. Fig. 1 illustrates the relative effectiveness of several inhibitors.

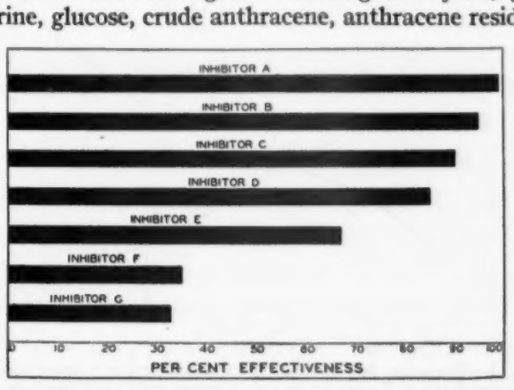


Fig. 1—Comparative values of a few inhibitors

Numerous attempts at chemical scale removal have been made by industry, itself, with varied results. Most of the failures were due to inadequate knowledge concerning the exact composition of the scale and the lack of suitable solvents for its removal.

Fig. 2—Motorized units transport chemicals, pumps, heaters and all necessary equipment to location of treatment

Advantages of Chemical Methods

Chemical cleaning offers several advantages, among which are the following:

1. Solvents penetrate where it is difficult or impossible for cleaning tools to operate; therefore, scale is removed from every part of the vessel.
2. Dismantling of equipment is unnecessary as solvent can be circulated through all parts of the vessel. This factor results in saving of labor and material, such as gaskets.
3. Chemically cleaned surfaces make possible long scale-free operation, as it leaves no nuclei for immediate scale formation.
4. No special plant equipment is necessary.
5. No safety hazards are encountered.
6. There is practically no metal loss.
7. Pits and corrosion are shown up and the chemical solvents clean out such depressions.

Before treating a unit, all possible information should be gathered concerning the metals encountered, type of service the unit must deliver and, most important, the

exact chemical and physical characteristics of the scale. These scale characteristics can be determined only by proper sampling and analysis. The ideal sample is a section of tube or plate from the hottest point in the vessel. However, this is usually unobtainable, so a sample (at least an ounce) of the most dense scale should be gathered, the sampler being certain that bare metal has been reached. Preliminary field tests are run and, if the scale is sufficiently soluble, the type of solvent can be designated at once. On a less soluble scale, or when corrosive secondary reaction is suspected, the sample is sent to the central laboratory where complete analysis is made. Here the sample is divided into two parts, one part going to the chemical laboratory, where it is tested for solubility in various solvents at different temperatures; also tests are made for disintegration, density, porosity, thickness, laminations, and chemical composition. The second part goes to the X-ray laboratory, where X-ray diffraction patterns are photographed and compared to standards;

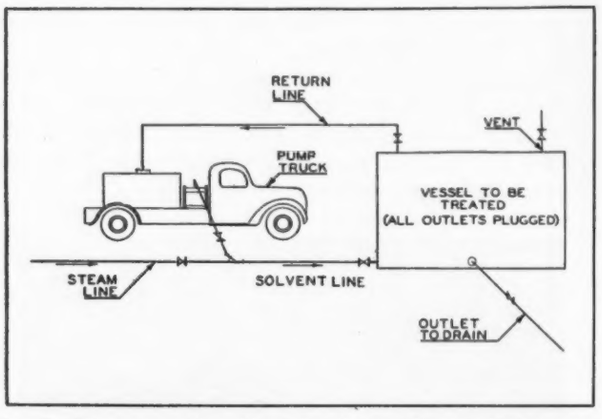


Fig. 3—Diagram of treating circuit showing typical hookup used in scale removal work

thus the sample of scale is shown in its true state of chemical combination. Table 1 lists some of the more common scales. Occasionally a scale is encountered whose pattern does not match any of the standards, in which case the X-ray analysis is supplemented by a spectrographic analysis which shows the metallic elements present. Thus, with definite knowledge of chemical and physical characteristics of the scale, recommendations can be made as to the strength and type of solvent to be used.

TABLE 1—TYPES OF HEAT-EXCHANGER SCALE DEPOSIT

Name of Scale	X-Ray Analysis	Where Found
Hydroxy-apatite	$Ca_{10}(OH)_2(PO_4)_6$	Boiler
Pectolite	$4CaO \cdot Na_2O \cdot 6SiO_2H_2O$	Condenser
Magnesium hydroxide	$Mg(OH)_2$	Brine evaporator
Iron oxide	Alpha FeOOH	Bubble tower
Iron oxide	Fe_3O_4	Oil cooler
Iron oxide	$Fe_2O_3 \cdot H_2O$	Polymerization cooler
Iron sulphide	FeS_2	Gas pipe line
Magnesium oxide	MgO	Boiler
Noselite	$Na_8Al_6Si_6O_{24} \cdot SO_4$	Heat exchanger
Hydrated magnesium silicate	$Mg_3Si_2O_7 \cdot 2H_2O$	Firetube boiler
Analcite	$NaAlSi_2O_6 \cdot H_2O$	Water-tube boiler
Aragonite	$CaCO_3$	Evaporator
Calcite	$CaCO_3$	Miscellaneous
Anhydrite	$CaSO_4$	Open-box heat exchanger

The vessel to be treated is drained and isolated from the rest of the system. Then connections are made for a filling line, a return line if necessary, and opening at top of unit to vent air and reaction gases.

Solvent is transported to the job in a specially constructed truck unit (Fig. 2), complete with tanks, pumps, heaters for solvent, proportioning devices for diluting the solvent to the desired concentration, and fittings for connecting onto customers' lines. The effectiveness of inhibitors used by the service company is well illustrated by the fact that the tanks are light gage steel and all piping on the trucks is ordinary steel. No lining or precautions are used except to be certain that the correct amount of the proper inhibitor is in the solvent.

Connections are made between the mobile service unit and the vessel to be cleaned, then the latter is filled with solvent at the required temperature. Inhibitors have recently been developed that will allow ample protection with solvent temperature as high as 200 F. After the vessel is filled the treating technique varies with conditions, the method of treatment being dictated by laboratory analysis of the scale and experience. After the solvent has done its work, it is drained to the sewer and the vessel is flushed down.

During treating procedure, the service company's engineer makes frequent tests to determine the progress of the treatment and the leveling off point at which no further reaction is taking place. An ordinary treating hookup is illustrated in Fig. 3, while Fig. 4 shows a solvent strength and temperature curve for a typical job.

Types of Equipment Cleaned

All types of heat-exchange vessels have been chemically cleaned. Power plants, refineries, distilleries, central heating plants, boats, ice plants, compressor stations, foundries, construction companies, hotels, theaters and schools show a fair cross-section of industries and utilities employing chemical cleaning service. To date, jobs include boilers, furnace-wall tubes, condensers, oil coolers, feedwater heaters, economizers, superheaters and flow lines.

The chemical cleaning of condensers has resulted in large savings to plant operators. Here the scales, although seldom thick, have a great effect on plant economy. The usual procedure is to introduce solvent into the steam space, then after reaction is complete, transfer the same solvent to the water side. The ratio of steam space volume to water side volume is usually about 2 to 1, so enough solvent is available to fill the water side twice. There are several variations of this technique.

Occasionally a flow line that is scaled up can be connected into the drain system so that the line may be opened while the vessel is draining, at no extra cost. When cleaning heaters, oil coolers, etc., where the same type of scale is encountered, it is often possible to connect

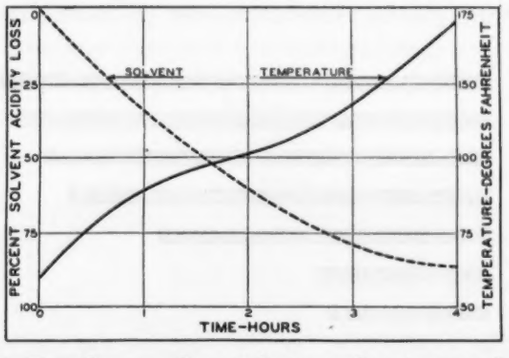


Fig. 4—Periodic sampling indicates solvent strength and temperature. Treatment continues until solvent strength becomes constant, indicating that reaction is completed

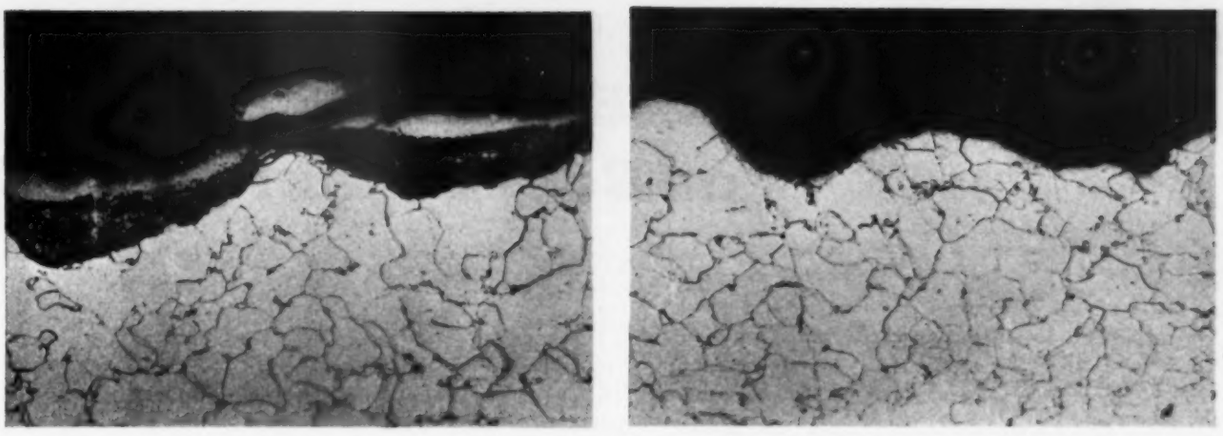


Fig. 5—Photomicrographs showing (left) boiler tube sample with oxide scale on internal surface and (right) boiler tube after chemical scale removal treatment

several vessels in series so that two or more units can be cleaned at the same time, thus making it possible to clean a complete "cycle" with one outage.

Where time is an important factor, chemical cleaning is practically a necessity. Depending on conditions, the time required for complete scale removal from boilers ranges from eight to twenty-four hours. Seldom, even on the largest, most complicated types, does the cleaning time run over twenty-four hours. It is sometimes an advantage to begin the treatment before the boiler cools below 200 F, thus a boiler can come down, be cleaned, and come up again without completely cooling off, and without opening handholes except for inspection.

Removal of Mill Scale and Welding Scale from Tubes

Chemical removal of scale is not only applicable to removal of scale accumulated in service, but also to removal of iron oxide usually found in new installations, as "mill scale" and scale resulting from welding operations. A treatment for such scale removal was made recently on a large 800-psi forced-circulation boiler before it went in service. Treatment in this case was for the removal of iron oxide only.

This unit has approximately 68,000 linear feet of $1^1/_4$-in. steam generating tubing and about 8000 linear feet of 2-in. economizer tubing. The circuits run from the rear bottom header, across the floor, up the front wall, and back across the roof into the rear top header. The headers are constructed without handholes and it would have been impossible to clean by any other method.

Analysis of the scale showed it contained the following iron oxides: Fe_3O_4, Fe_2O_3, FeO and alpha FeOOH.

Connections were made to service truck and solvent pumped into the boiler, which required 5080 gal to fill. During the treatment, tests were made at different points to determine the per cent of the original solvent still remaining. Some of these tests were as follows:

34 min after filling, solvent strength 77 per cent at lower right header
40 min after filling, solvent strength 91 per cent at lower left header
45 min after filling, solvent strength 91 per cent at lower rear header
45 min after filling, solvent strength 82 per cent at lower front header
50 min after filling, solvent strength 84 per cent at upper left header
65 min after filling, solvent strength 66 per cent at upper right header

Constant check was kept on solvent strength and after 6 hr the concentration had leveled off at about 29 per cent. The boiler was then drained and filled with hot water to wash out any dissolved solids. An analysis of the spent solvent solution shows that approximately 500 lb of iron oxide had actually been removed. This analysis does not take into account any scale which sloughed off and was carried out in suspension. Fig. 5 shows photomicrographs made in the laboratory from samples of tube surface such as employed in this unit. The scale is readily apparent in the left-hand photograph, whereas the right-hand photograph, taken after chemical cleaning of the sample, shows sound metal.

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An Example of War-Time Expediency in Boiler Plant Layout

Because of the inability to obtain new boilers such as called for in the plans, one new and two second-hand units, all of different types and sizes had to be employed on short notice. Two of these burned pulverized coal and the third was stoker-fired. The available forced-draft fan equipment also led to adoption of an unusual arrangement in the early stages of construction and operation.

INGENUITY displayed as a result of war-time scarcities and priorities in the power equipment field was well exemplified by the boiler problem encountered in the construction of the aircraft manufacturing and assembly plant of the Curtiss-Wright Corporation located at Louisville, Ky.

The design and structural details as worked out by Albert Kahn Associated Architects and Engineers, Inc., of Detroit, had been approved and construction contracts let, when it was found that no new boilers such as had been planned were available. Without knowing what boilers and other equipment might be obtained from used sources, it was obvious that work on the boiler house could not proceed until such information was available to the designing engineers to permit adapting the layout and drawings to conform to the new conditions.

Accordingly, the engineers' representatives started a countrywide search for boilers that might prove suitable. They came upon a 30,000-lb per hr Edge Moor boiler that had been installed many years ago in the "Old Hickory" plant in Tennessee (initially a World War I project) and an old Union boiler of 65,000 lb per hr capacity that could be spared from another plant. It was further discovered that a new 67,500-lb per hr Riley boiler could be routed from a later Curtiss-Wright project to serve this more immediate need. Not only were the boilers of different design and capacity but they were fired differently, involving both pulverized coal and a traveling grate stoker. This variety of equipment involved re-designing the boiler-house on very short notice. How well this was done is shown by the photograph on the opposite page.

Both Pulverized Coal and Stoker Firing Involved

The Riley unit at the extreme left is fired with two flare-type horizontal burners, supplemented by two steam-atomizing oil burners; the Union boiler in the center is also pulverized-coal fired, but with one coal burner and one supplementary oil burner; whereas the Edge Moor boiler at the right has a Coxe stoker. Although designed for different steam pressures, the operating pressure of 160 psi was dictated by the greatest allowable pressure on any of the three units, and this was sufficient for the plant's steam requirements which involved chiefly space heating and process work. None of the steam is used for the production of electricity which is supplied from an outside source.

The old Edge Moor unit came rolling in on cars ahead of the other two. It was immediately set up on the operating floor, while construction of the building was going on all around it, but it came without either a forced-draft or an induced-draft fan.

Next to be received was the old Union boiler which had a forced-draft fan, but no induced-draft equipment.

Last came the new Riley unit complete with forced and induced-draft fans, burners, and its own stack.

Despite the handicaps, the old Edge Moor boiler was delivering steam to the plant within twenty days after its arrival and continued to deliver steam while the other two boilers were being set up.

Supply of Draft Becomes Involved

First, a temporary induced-draft fan and a temporary stack were erected for the Edge Moor unit. Then a temporary duct was run from the forced-draft fan on the Union boiler, which was located between the other two, over to the Edge Moor, in order to permit forcing the latter; and, to compensate for the lack of an induced-draft fan on the Union boiler, another temporary duct was run to it from the Riley unit, with a damper cut-off. Thus, the Riley's own induced-draft fan served both that unit and the Union boiler and the latter's forced-draft fan served both the Union and the Edge Moor.

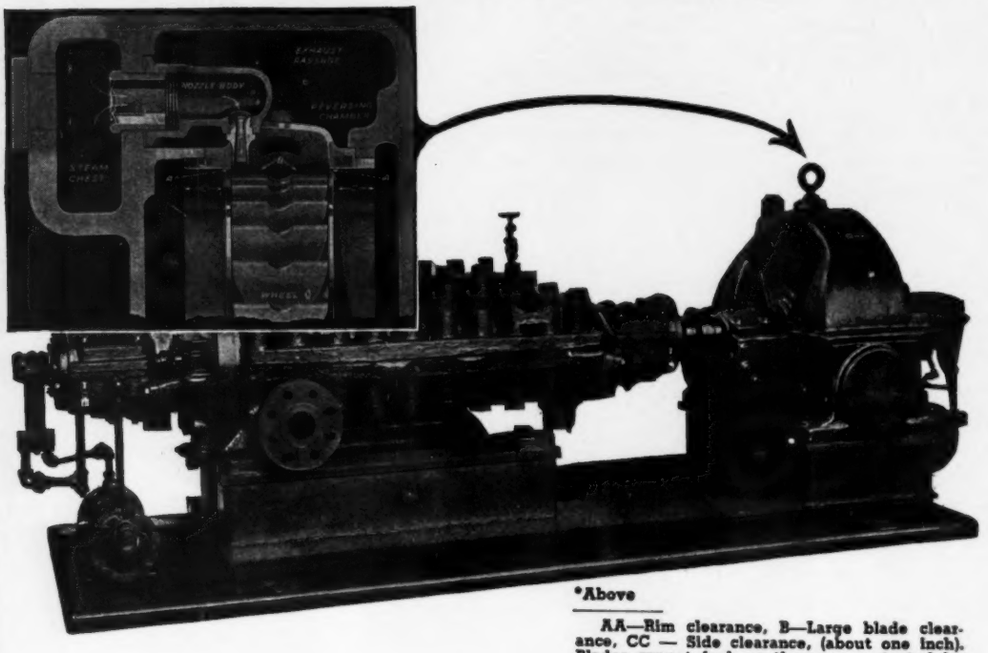
In due course, permanent fan equipment arrived and replaced these makeshift hook-ups; yet, despite the "Rube Goldberg" character of this ingenious arrangement of fans, steam service to the plant never once faltered from the time the old Edge Moor first went into service. From the time the old Union went on the line, there was at least one boiler continuously in service and one for standby.

The whole performance hit a high note in achieving uninterrupted service under most difficult and trying conditions, which at times taxed the ingenuity of the engineers. While there are probably numerous other war-time installations that have been faced with similar problems of fitting used equipment into new plants it is doubtful if many have resulted in as pleasing appearance as this boiler room.

An exterior view of the completed power plant is shown on the cover of this issue.

Three different types and sizes of boilers involving different methods of firing went into this war plant boiler room.

TERRY



*Above

AA—Rim clearance, B—Large blade clearance, CC — Side clearance, (about one inch). Blades cannot foul, as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large that end-play from excessive external thrust cannot damage wheel.

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T-1133

THE TERRY STEAM TURBINE COMPANY
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Determination of Steam Purity by the Electrical Conductivity

This is an elementary discussion of the factors involved together with simple practical directions for making determinations in the field, such as should enable operators to ascertain the extent to which carryover exists.

ELECTRICAL conductivity of a liquid or solution is measured by determining the electrical resistance over a definite path through the liquid. Conductance is the reciprocal of resistance. As the unit of resistance is the ohm, the unit of conductance is 1/ohm or the mho. The "resistivity" of a fluid is defined as the resistance between two plates one square centimeter in area and spaced one centimeter apart. The reciprocal of this value is termed "conductivity." For very dilute solutions such as condensed steam, a conductivity cell having plates somewhat larger than this and more closely spaced is used. The usual cell employed has a factor of 0.1. This means that resistance measured must be multiplied by 10 to get the true resistivity or, conversely, the conductance as measured must be divided by 10 to get the true conductivity. A cell factor correction is provided in the instrument usually used and the scale reading gives the true value of resistivity or conductivity.

As the conductivity of condensed steam is ordinarily only a small fraction of a mho, the values are reported in $^1/_{1,000,000}$ mho or micro-mhos (mmho).

The distinction between the terms conductance and conductivity should be noted. Conductance is a property of a particular specimen of a substance and is affected by the dimensions of the specimen. Conductivity is a specific property of a substance or the conductance of a specifically sized specimen.

Dissolved Gases Must Be Removed

The determination of steam purity by electric conductivity methods would appear to be an ideal way to measure small quantities of dissolved salts. The great difficulty lies in the fact that dissolved gases, principally ammonia, NH_3, and carbon dioxide, CO_2, both of which are conductive, are often present in the samples of condensed steam. These gases must be removed from the steam sample or their quantity must be determined and suitable corrections made to the observed conductivity reading of the sample.

The removal of these gases is not an easy matter. CO_2 may be removed by boiling; but only by prolonged boiling, with consequent concentration of the sample, can the NH_3 be reduced to a negligible amount. The simplest way to remove the gases is, therefore, to boil the sample until it is reduced to about one-fourth of its initial volume; cool, and measure the conductivity, and then correct back to the original volume. The following example will illustrate this method:

Original volume (1000 ml), km = 8.5 mmho
Final volume (260 ml), kr = 4.6 mmho
km designates conductivity as measured and kr conductivity of the residue.

$$\text{Corrected conductivity, } k = \frac{260 \times 4.6}{1000} = 1.2 \text{ mmho}$$

The correction to be applied to the observed readings over the period represented by this sample would be 8.5 − 1.2 = 7.3 mmho.

While this appears to be a very simple procedure, extreme care must be taken to avoid contamination of the sample during boiling and cooling. Boiling should be at a low rate to insure against any spattering or carryover of water. A three-liter pyrex flask should be used and the rate of evaporation regulated to about 350 ml per hour. The flask should be covered by a small beaker inverted over its mouth. At the end of the boiling period the sample must be cooled below 100 F or within the range of temperature adjustment of the instrument. As the sample is cooled, the steam remaining in the flask will condense and air will be drawn into the flask. Care should be taken that the sample is not contaminated by dust or gases that are drawn in with this air. If, for example, the boiling is done in a chemical laboratory, acid or ammonia fumes that may be present will ruin the test.

After cooling, the sample should be transferred to the conductivity cell container. A 250-ml residue should permit twice flushing with the sample and three check measurements. The conductivity should be read immediately after the sample is put in the cell container. It will be noted that there is an upward drift of conductivity with time as the sample stands in the container. This is due to gas absorption and also may be due to solution of material from the cell which may have recently been used in the measurement of less pure water. If the three measurements give successively lower values, the lowest value should be used. It should be noted that any error of this method is on the plus side for the following reasons:

1. It is impossible to remove completely dissolved gases by boiling.
2. The water will dissolve in some measure the material of the container and, in fact, any material with which it comes in contact.
3. In the process of cooling, contaminating gases are unavoidably absorbed from the atmosphere.
4. Absolute cleanliness of the containers is not attainable and each time a sample is transferred, some contamination results.

Measurement of the amount of water remaining after boiling should be done after the measurement of conductivity in order to eliminate that source of contamination.

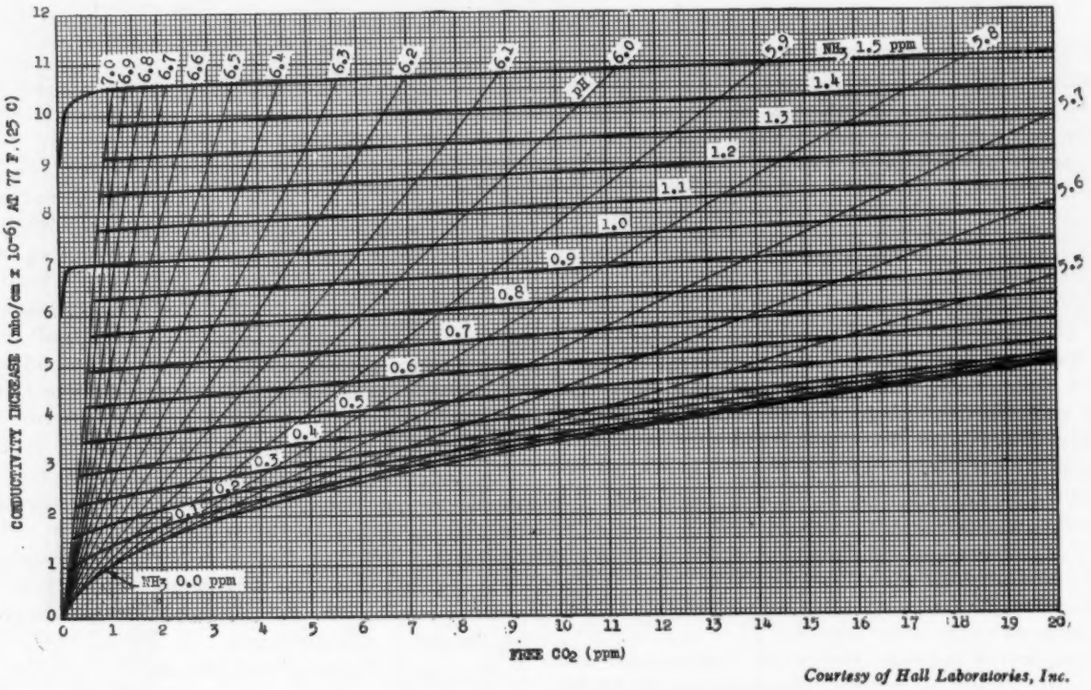
Hard rubber conductivity cells are not suitable for this method of measurement as the material dissolved from the rubber affects the conductivity. When used as a flow cell with a relatively high rate of sample flow, say 500 ml per min, the effect of such contamination is negligible, but if the sample is permitted to stand in contact with the cell, the conductivity mounts at such a high rate that it is almost impossible to measure it.

Apparatus for continuous degassing of steam condensate has been developed and one type is available commercially. However, as complete degasification is not assured, determinations for residual ammonia must be made and corrections applied. With high initial concentration of ammonia, considerable steam must be vented and the sample in some measure concentrated. For accurate results it would be necessary to measure the amount of steam vented and apply corrections.

If the sample contains no NH_3 and only CO_2, the problem of degassing is somewhat simpler. The steam may be condensed and cooled to about 250 F under pressure and then flashed in a vented chamber. The water is then drained through a second cooler and passed through the conductivity cell. The sample must be analyzed for residual gas and the necessary correction applied. At present there does not appear to be any commercial device that employs this principle, although one suitable for field use has been designed. When high concentrations of NH_3 are present, this device will remove approximately half of it. This is useful as it reduces the concentration of gases to values at which the corrections are more certainly known.

Determination of the correction for dissolved gases in the steam sample "as collected" may be done with sufficient accuracy if the quantities of gases are low; for example, not exceeding 10 ppm of CO_2 and 0.5 ppm of NH_3. The measurement of these gases is by chemical means, though only simple apparatus is required.

For the determination of CO_2, a 100-ml sample of water is used. A few drops of phenolphthalein indicator solution is added. If the solution turns pink, no CO_2 is present. If it does not turn pink, a solution of N/44 Na_2CO_3 is added, drop by drop, until a faint pink coloration appears. The number of milliliters of the Na_2CO_3 solution used multiplied by 10 equals the CO_2 in parts per million. When the amount of CO_2 is low, say below 5 ppm, a larger sample should be used and the results corrected by the factor, $\frac{100}{\text{ml of sample}}$. The sample should be freshly drawn and the titration made quickly in order to reduce errors incident to exposure to the atmosphere. The titration should be made in a beaker or bottle, placed over a white surface so that the faint pink end-point can be easily detected.



Courtesy of Hall Laboratories, Inc.

Effect of Ammonia and Carbon Dioxide on Conductivity of Steam Condensate

The determination of NH_3 is based on the formation of a yellow color that is produced when a solution called Nessler reagent is added to a sample. The intensity of the color varies with the concentration of NH_3 and the amount present is estimated by comparing the color of the sample with that of known standards.

A small field kit is available that uses artificial standards with which the treated sample may be compared and the NH_3 content estimated. The test is simple. A sample of 50 ml is put into a special Nessler tube and 1 ml of Nessler solution is added. After ten minutes the color of treated sample is compared with that of the known or artificial standard.

The corrections for the dissolved gases may be made by means of the curves of the above chart.[1] This

[1] Prepared by the Hall Laboratories.

chart gives the combined correction for CO_2 and NH_3. The values of pH shown are those resulting from the various proportions of CO_2 and NH_3.

After the corrections have been determined and applied and a net value for specific conductivity obtained, it only remains to convert this value in mmho to parts per million. For this conversion a representative sample of boiler water is necessary. The total dissolved solids of this sample must be known, preferably as determined by evaporation.

To a 1000-ml portion of distilled water, freshly boiled and cooled, successive portions of 1 ml each of boiler water are added. The conductivity is measured between each addition. After about 5 additions, the increase in conductivity per milliliter of boiler water should become constant and this value is taken.

The arithmetical procedure is best illustrated by a specific example. Thus, let it be assumed that the boiler water sample has 1200 ppm of dissolved solids. The record of conductivity increases per milliliter of boiler water may be as follows:

Original water, conductivity	=	2.5 mmho
After first addition, conductivity	=	4.5 mmho
After second addition, conductivity	=	6.6 mmho
After third addition, conductivity	=	8.8 mmho
After fourth addition, conductivity	=	11.0 mmho
After fifth addition, conductivity	=	13.2 mmho

Each of the last three additions gives an increase in conductivity of 2.2 mmho. As the boiler water had 1200 ppm, each milliliter had 1.2 mg (1 ppm = 1 mg per liter and 1200 ppm = 1200 mg/l and 1 ml = 1.2 mg) the addition of 1.2 mg per liter to the water (1.2 ppm) resulted in an increase in conductivity of 2.2 mmho. One mmho therefore has a value of 1.2/2.2 = 0.545 ppm.

The value of this conversion factor ranges from 0.5 to 0.6 and the value 0.6 may be assumed if it is not desired to make the more accurate determination as described above.

In this discussion it is attempted to explain as simply as possible an application of the conductivity method for determination of steam purity. The directions are made complete enough so that an operator after some practice can obtain reasonably accurate results. For most field work involving putting a boiler unit in operation and determining the limits of water concentration, water level and rating for satisfactory operation, the knowledge of the absolute purity is not required. The steam conductivity as measured is usually sufficient for that purpose. The readings taken at low ratings if steady may be considered as a normal value for clean steam. This reading is analogous to a steam calorimeter normal. Any great or erratic variation from this value with changes in operating conditions may be regarded as indicating carryover.

One word of caution is necessary in the interpretation of fluctuations in conductivity. It must be kept in mind that the gases found in the steam come from the feedwater rather than the boiler water. That is, when the feedwater is subjected to the higher temperature of the boiler water, these gases practically flash off and go out with the steam. The concentration of gas in the steam is, therefore, a function of the rate of feed of water to the boiler. Thus, when the rating is increased, the water level tends to rise and the feed, if automatically controlled, may momentarily be checked. The rate of gas flow to the boiler is reduced with the reduction in feed and the amount of gas in the steam will be reduced. Conversely, at a sudden drop in rating the conductivity may rise due to the fact that more water is fed and more gas added to the steam. Where the gas correction is high, fairly large fluctuations in measured conductivity may result which might be interpreted as indications of carryover.

The appended list gives the apparatus required for the determinations described. These are minimum requirements and include no spare equipment:

1—steam condenser or cooler with or without flash chamber.
1—conductivity bridge for cell constant 0.1 and with temperature compensation.
1—cell, with container arranged for continuous flow, of glass type with platinum electrodes, constant 0.1.
1—thermometer 0 to 100 C.
1—1-liter flask.
1—3-liter flask for boiling sample to remove gas.
1—500-ml graduate.
1—600-watt electric hot plate with flask support.
1—200-ml beaker.
1—1000-ml flask with tubulatures for cell and burette.
1—25-ml burette.
1—set of 3 Nessler tubes.
1—NH_3 comparator with standards for 0 to 1.0 ppm NH_3.
1—500-ml bottle of Na_2CO_3 $N/44$ standard.
1—500-ml bottle of Nessler reagent APHA standard.
1—250-ml bottle phenolphthalein.

EQUIPMENT SALES

as reported by equipment manufacturers to the Department of Commerce, Bureau of the Census

Boiler Sales

Stationary Power Boilers

	1943 Water Tube		1942 Water Tube		1943 Fire Tube		1942 Fire Tube	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan.	11	64,169	197	1,590,796	18	22,854	52	59,476
Feb.	35	175,308	216	1,467,900	244	151,055	58	83,647
Mar.	32	149,983	268	1,487,505	17	25,043	60	62,679
Apr.	96	364,146	422	2,402,579	22	33,231	46	61,054
May	127	683,052	156	1,243,328	9	14,106	57	83,147
June	‡164	‡684,556	139	847,562	‡25	‡41,073	57	74,231
July	31	222,253	133	880,430	19	10,985	45	53,596
Aug.	51	311,448	113	933,660	31	41,311	26	30,228
Jan.-Aug., incl.	547	2,654,915	1644	10,853,760	385	339,658	401	508,058

* Includes water wall heating surface. ‡Revised.

Total steam generating capacity of water tube boilers sold in the period Jan. to Aug. (incl.) 1943, 25,618,000 lb per hr; in 1942, 92,219,000 lb per hr.

Marine Boiler Sales

	1943 Water Tube		1942 Water Tube		1943 Scotch		1942 Scotch	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan.	627	2,261,623	237	1,119,437	1	1,080	–	—
Feb.	31	102,404	70	347,324	–	—	–	—
Mar.	208	602,051	1,676	7,827,106	1	2,565	–	—
Apr.	19	85,244	236	848,986	2	5,130	1	161
May	1,028	‡5,147,064	364	1,473,354	3	6,401	2	868
June	895	4,241,507	255	876,146	1	2,565	–	—
July	474	2,300,725	242	1,038,918	1	2,565	–	—
Aug.	1,171	4,464,125	204	665,660	4	7,730	–	—
Jan.-July... incl.	4,453	19,204,743	3,284	14,196,931	13	28,036	3	1,029

* Includes water wall heating surface. ‡ Revised.

Total steam generating capacity of water tube boilers sold in the period Jan. to Aug. (incl.) 1943, 206,023,000 lb per hr; in 1942, 117,098,000 lb per hr.

†Mechanical Stoker Sales

	1943 Water Tube		1942 Water Tube		1943 Fire Tube		1942 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan.	134	48,448	87	42,876	457	31,623	159	24,135
Feb.	104	34,858	131	55,001	575	83,673	185	26,889
Mar.	114	48,367	84	46,055	573	77,951	210	31,329
Apr.	99	33,781	102	49,061	433	64,172	313	39,877
May	96	39,640	125	44,069	414	57,889	206	33,566
June	‡118	‡61,415	123	48,267	‡367	‡49,062	296	49,760
July	99	51,414	131	59,376	381	53,040	297	45,902
Aug.	68	72,197	94	40,619	440	61,302	295	49,725
Jan-July,. incl.	832	390,120	877	385,324	3,640	478,712	1,961	301,183

† Capacity over 300 lb of coal per hr. ‡ Review.

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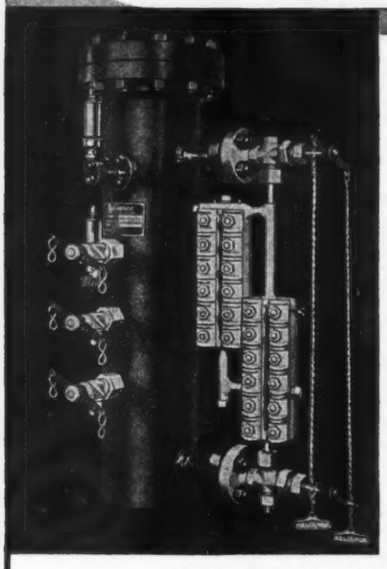

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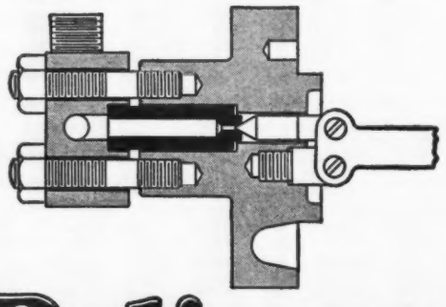

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DAVIS STRAINERS contribute to uninterrupted operation of pumps, engines, turbines, valves—every device that might be damaged by pipe scale, joint compound and other foreign particles. Investment in Davis Strainers is like buying insurance on your plant.

Davis Strainers permit an unobstructed flow of steam, gas, or liquids. They can be supplied, for pressures up to 1500 lbs. Self-cleaning and Basket types meet most requirements. Special Davis Strainers built to meet unusual conditions.

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Davis No. 75, below, left. Foreign matter trapped in the cylinder may be blown off. It is seldom necessary to remove the screen from the strainer when cleaning.

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

How to Maintain Electric Equipment in Industry

The procedures outlined in this substantial manual, just issued by General Electric Company, are intended to help industrial plants get maximum performance and longest life out of their General Electric equipment through proper upkeep.

The volume comprises 20 sections on How to Maintain: Battery Trucks; Bushings; Cable and Wire; Capacitors; Diesel-Electric Locomotives; Electric Furnaces; Fuse Cutouts (Distribution Type); Industrial Control; Instruments; Lighting; Lightning Arresters; Midget Heaters; Mine Locomotives; Motors and Generators; Rectifiers; Regulators; Switchgear; Transformers; Turbines; and Welders; also sections on Insulation; Technical Data; Renewal Parts; and G-E Service Shops. Preventive-maintenance schedules and trouble-shooting charts are included in nearly all types of apparatus listed. Photos and diagrams lavishly illustrate the text and indicate what constitutes good maintenance procedure and some of the troubles that may arise from improper care.

The book contains 372 pages, size 8 × 10½, and is bound in blue buckram. Price $1.75.

Manual of A.S.T.M. Standards on Refractory Materials

This latest compilation of all A.S.T.M. Standards on Refractory Materials is the fifth sponsored by A.S.T.M. Committee C-8 on Refractories. It includes new standards for air setting refractory mortars, fireclay plastic refractories both for boiler and incinerator services, methods of test for measuring the shrinkage, spalling and workability index of fireclay plastic refractories, and a method for measuring the thermal conductivity of insulating fire brick.

Seven specifications on refractories for various types of service are given in the book. There are two classifications of materials and the remaining 16 standards give various methods of testing for fireclay refractory brick, fireclay plastic refractories, insulating fire brick and for various types of refractory materials. The latter includes tests to determine P.C.E., permanent linear change, cold crushing strength, warpage, porosity, true specific gravity. An important part of the book is the section giving ten industrial surveys of refractory service conditions covering: Open-Hearth Practice; Electric Furnaces Used in Steel Manufacture; Malleable Iron Industry; Copper Industry; Lead Industry; By-Product Coke Ovens; Lime Burning Industry; Glass Industry; Portland Cement Industry; and Stationary Steam Boilers. Other data in the manual give standard samples of refractory materials for chemical analysis, and for pyrometric cone equivalent.

This 210-page publication, size 6 × 9, is available at $1.50, heavy paper cover; cloth, $1.75.

Patent Law

By Chester H. Biesterfeld, B.Ch.E., M.P.L.

In presenting the various subjects of the patent law, the author of this book tries to explain the basic principle or rule underlying the subject under discussion, and to illustrate this by the citation of leading cases and by quotation of pertinent sections therefrom. Considerable attention has been devoted to an analysis and classification of the decisions on certain subjects in order to present them according to the principles they support. Especial attention has been given to the inclusion of recent decisions of the courts bearing on the various subjects treated, so that the reader may have the benefit of current legal opinion.

Those who do not possess a professional training in law, but who have frequent occasion to acquire a detailed understanding of some proposition of the patent law in connection with their work as chemists or engineers, will find it helpful to have within easy reach an explanation of the subject of inquiry together with pertinent quotations from the decisions. The book includes 21 succinctly written chapters, a bibliography, a 16-page Table of Cases and a 5-page index. It contains 225 pages, size 5½ × 8¼, bound in dark blue buckram. Price $2.75.

Proceedings of the 37th Annual Meeting of the Smoke Prevention Association of America

This typescript volume contains a report of the proceedings of the 1943 Annual Meeting of the Smoke Prevention Association of America held in Pittsburgh, Pa., on June 8 to 11, inclusive. Sixteen papers were presented at the convention. Among the topics concerned were: wartime fuel conservation, statistical methods for controlling coal quality, smoke tendencies in coals of various ranks, and, smoke seen through the eyes of a chemist. Two important papers deal with fly-ash and three more cover different aspects of the application of overfire air. Smokeless combustion of wood waste in power furnaces is the subject of another paper, and there are others dealing with surveys of air pollution and smoke control, and recommendations for smoke abatement.

The book contains 151 pages, size 8½ × 11, and is bound in paper covers.

The Steam Boiler Yearbook and Manual

Edited by Sidney D. Scorer, A.M.E. Mech. E., M.I. Mar. E.

The 1943 edition of "The Steam Boiler Yearbook and Manual" follows the principles and style established in its inaugural edition last year by providing a descriptive review of established steam-boiler practice and a summary of research and development work carried out during the preceding year, as recorded in the transactions of numerous technical societies on both sides of the Atlantic.

The plan of arranging the book in two parts is maintained. Part I, which comprises a 352-page section dealing with British steam-generating equipment and present-day practice, contains 20 chapters. In this section a new chapter on special-type water-tube boilers has been added. Part II consists of a 141-page section comprising 31 important technical papers or articles published during 1942. In view of wartime needs, particular attention has been given to subjects such as fuel economy, equipment maintenance, and heat utilization and conservation. Information is also given on the use of low-grade coal, German stoker practice, soot blowers, caustic embrittlement, boilers and combustion in the U. S. A., and a short chapter on German boiler design. The practice of briefing articles and the use of small type permit the inclusion of special subjects not usually encountered in a book covering such a wide field.

The book contains 522 pages, size 5½ × 8½, and the text is illustrated with 396 drawings and charts. Price 20*s*. plus postage ($4.50 approximately; two months delivery).

X-Rays in Research and Industry

By H. Hirst, Nat. Phil. D., B.Sc. (Eng.)

The text of this little volume is substantially the subject matter of a series of lectures given before the Melbourne University Metallurgical Society in 1941. The purpose of these lectures was to indicate problems in industry and research, particularly those coming within the field of physical metallurgy, for which the application of X-ray methods offer a solution; to indicate the most suitable methods of approach to these problems; and to describe in detail the actual practice and calculations of X-ray technique.

The book offers a thorough and self-contained study of the principles of X-ray technique and the versatility of its application. Chapter headings are as follows: Production of X-Rays; Properties of X-Radiation; Structure of Crystals; Methods of Crystallographic Examination; Applications of X-Ray Methods; and Industrial Radiography. The text is cogent and to the point, and the use of small type allows a great deal to be said in the 130 pages which comprise the book which is admirably illustrated with 82 linecuts and halftones.

The book is bound in grey buckram; size 4¾ × 7½. Price $2.50.

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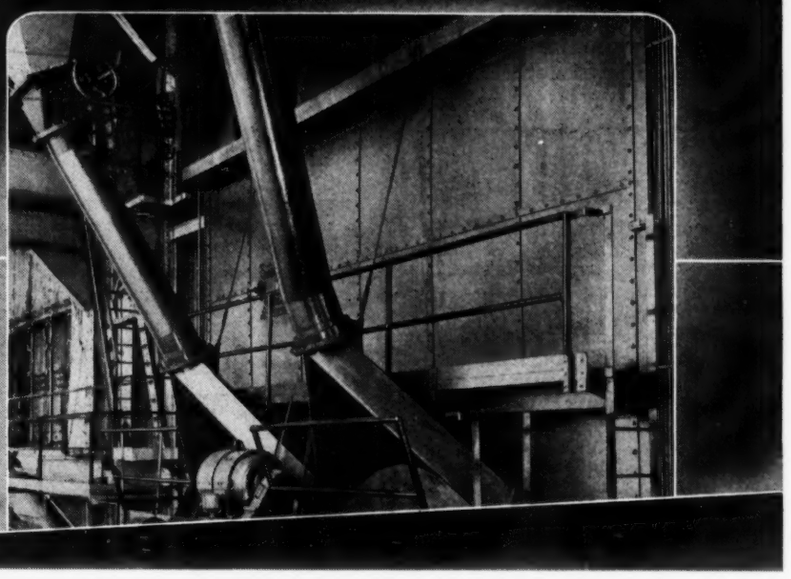

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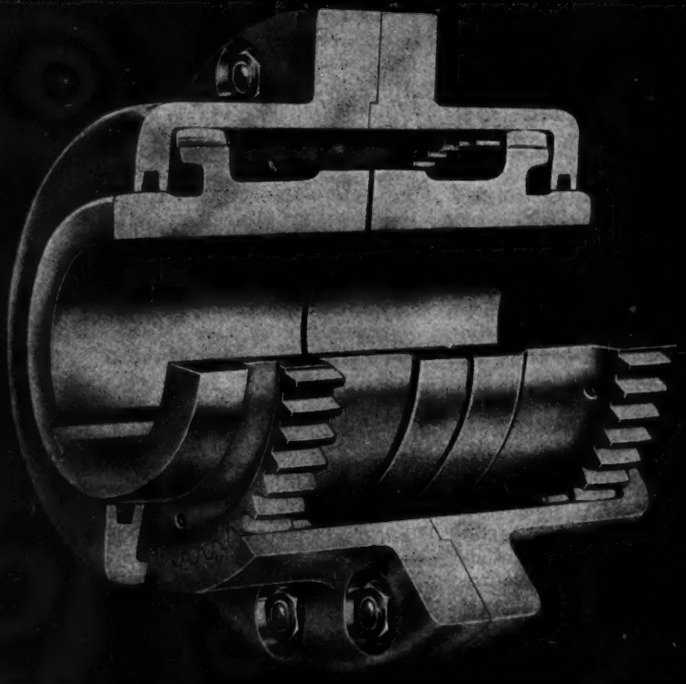

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FLEXIBLE COUPLINGS

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George T. Ladd Dies

George T. Ladd, who in 1920, as president of the Ladd Water-Tube Boiler Company, made important contributions to the design and application of very large steam-generating units, died on October 3 after a lengthy illness at the Elizabeth Steel Magee Hospital, Pittsburgh. He was seventy-two years old.

His long and successful career represented a combination of engineering achievements, executive responsibilities and diversity of corporate interests.

Born in Edinburgh, Ohio, he was graduated from Sheffield Scientific School, Yale University, in 1891 and took his degree in mechanical engineering at Cornell University in 1895. First employed by the Pittsburgh and Lake Erie Railroad, he later became associated with the Brooks Locomotive Works at Dunkirk, N. Y., and from 1898 to 1909 was with the Bass Foundry and Machine Company of Fort Wayne, Ind., as mechanical engineer in charge of engine and boiler sales.

The following year he established the Ladd Water-Tube Boiler Company. When this was acquired by the predecessor of Combustion Engineering Company in 1925 he became a director of the acquiring company and continued as a director of Combustion Engineering Company until his death.

During World War I he served as a lieutenant-commander in the Ordnance Division of the Navy Department and was in charge of construction of the gun mounts for the 14-in. railway guns which were used effectively against German fortifications. His interest in ordnance continued through later years and in the present war he was a member of the advisory board in the Pittsburgh Ordnance District.

Mr. Ladd was an officer or director of many companies. Among these were: president of the United Engineering and Foundry Company; president of the Ladd Equipment Company of Pittsburgh; chairman of the board of the Pittsburgh Testing Laboratory and of the Woodrings-Verona Tool Works; and chairman of the executive committee of the Pennsylvania Air Lines.

His directorships included the First National Bank of Pittsburgh, Pittsburgh Steel Company, Columbia Enameling and Stamping Company, Combustion Engineering Company, Flannery Bolt Company, Heyl & Patterson, Inc., National Supply Company, Follensbee Steel Corporation, Westinghouse Airbrake Company, Duff-Norton Mfg. Company and the Union Switch and Signal Company.

In addition to the foregoing, he was a trustee of Carnegie Institute of Technology and of Bucknell University; also the Elizabeth Steel Magee Hospital and the Allegheny General Hospital. Bucknell last year conferred upon him the degree of doctor of engineering, and recently further honored him by naming its mechanical engineering department after him. He was long active in the local affairs of Pittsburgh as a director of the Pittsburgh Chamber of Commerce, the Tri-State Industrial Association and the Pittsburgh Tourist and Convention Bureau.

Society memberships included the American Society of Mechanical Engineers, of which he was a fellow; the Engineering Society of Western Pennsylvania, of which he was past-president; the American Iron and Coal Institute; the United States Naval Institute; and the American Geographic Society. He was also a member of numerous clubs.

Mr. Ladd's immediate survivors are his wife, Mrs. Florence B. Ladd, of Coraopolis Heights, Pa.; a son, Tallman Ladd, who is associated with Combustion Engineering Company; a brother Dr. L. W. Ladd of Cleveland; and a sister, Mrs. Walter A. Barrett of Fort Wayne, Ind.

Mandatory Conversions Suspended

The recent suspension of its program of conversion of industrial and commercial oil-burning equipment to coal, says the Petroleum Administration, was due entirely to present uncertainties in the coal situation and should not be construed as meaning that we are "over the hump" as far as the oil supply is concerned. It is emphasized that war developments may make it necessary later to resume the conversion program, especially as the United States is still faced with an overall shortage of oil.

The announcement pointed out further that the suspension does not apply to conversions now in process, inasmuch as the supply program for the coming winter has been based upon the assumption that requirements for oil will be reduced by the amount now used by the facilities under conversion.

Reviewing the conversion program to date, Deputy Administrator Ralph K. Davies points out that industrial conversions have resulted in savings equivalent to 176,500 bbl of fuel oil per day of which over 75 per cent has been effected in 17 eastern states and the District of Columbia.

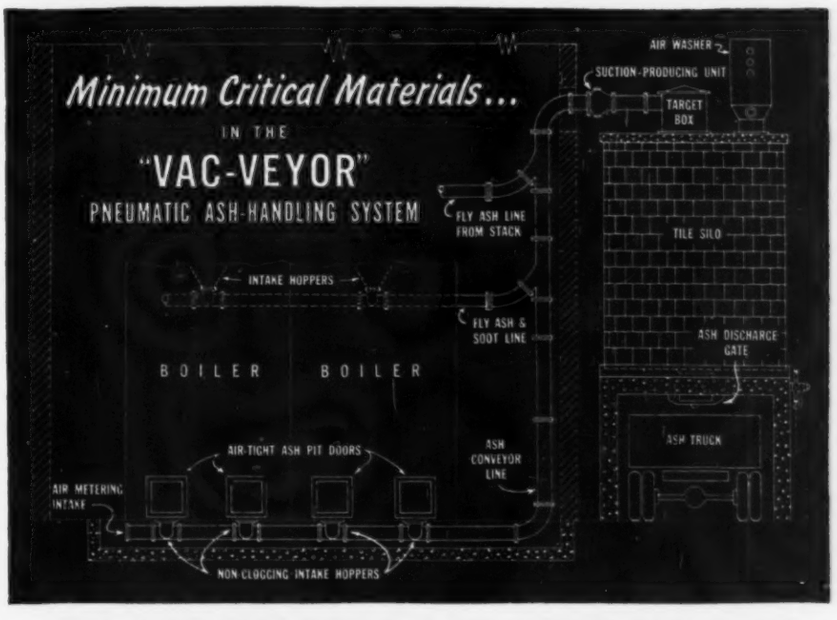
Gas Pipe Line Authorized

To help in relieving the natural gas transportation situation in certain sections of the Southwest, the Federal Power Commission has authorized the immediate construction of a 231-mile, 26-in. pipe line by the Cities Service Transportation and Chemical Company from the Hugoton gas fields to the Blackwell compressor station in Kay County, Okla. Initially this will increase the natural gas supplies by 140 million cubic feet per day, and by the installation of additional compressor facilities it is expected later to increase this to 240 million cubic feet.

Coal Production Still Much Below Demand

The present rate of coal output, in the opinion of Solid Fuels Administrator Ickes, furnishes unmistakable evidence that, under existing conditions, the coal industry cannot increase production to levels that will meet the war-time requirements for several months immediately ahead.

Production of bituminous coal for the week ending September 25 was estimated



Write us today for complete details

Designed to fill today's needs in either new installations or oil-coal conversion, this pneumatic ash handling system offers numerous advantages.

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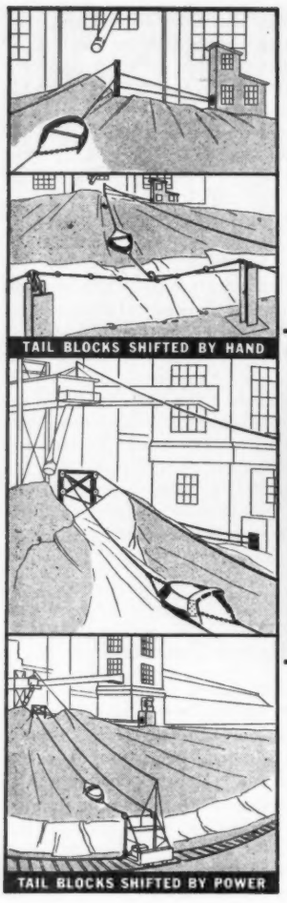
MANUFACTURERS AND ERECTORS OF COMPLETE COAL AND ASH HANDLING SYSTEMS



SOUND SOLUTION to COAL STORAGE PROBLEMS

SAUERMAN Drag Scraper Systems provide the safest, most flexible method of storing and reclaiming coal. Two types of installations, illustrated at left, provide greater storage capacity on areas of any size or shape.

One-man operation, under clean, attractive conditions. Homogeneous pile is formed without segregation, thus eliminating danger of spontaneous combustion.

The ¾ cu. yd. Sauerman installation pictured above handles an average of 200 tons per day, either storing or reclaiming, but when shipments are heavy stocks out as much as 450 tons. Present storage of 8000 tons on 35,000 sq. ft. is by no means maximum which scraper can store on this space.

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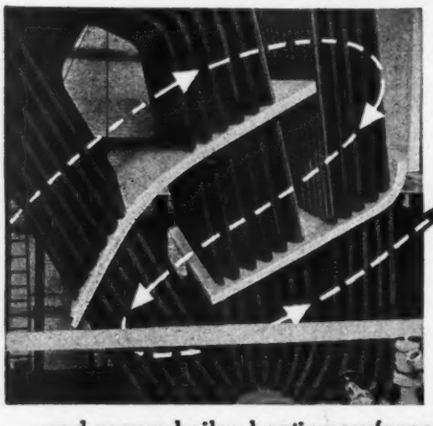


Satisfy Hungry Heating Surfaces

...and many boiler heating-surfaces are literally and unnecessarily starved. They need Enco Baffles to increase heat absorption, to boost efficiency and to increase steam output. Enco Baffles revitalize boilers by providing streamlined cross-flow of gases over the tubes, and by eliminating eddy currents, bottlenecks and dead gas pockets. Bulletin BW40 gives further details. It is yours on request.

THE ENGINEER COMPANY

75 WEST STREET (Enco) NEW YORK, N.Y.

at 12,075,000 tons, or an increase of only 25,000 tons over the preceding week, despite almost the heaviest demand in history. Requirements this year are roughly 5 per cent greater than those of 1942 but so far the production has been less than 2 per cent over that of the corresponding period last year. If production were to meet requirements it would have to be increased by an average of 500,000 tons per week for the remainder of the year.

The output of low-volatile coal has not kept pace with increasing demands for such coal by steel mills and certain other war industries. Also, the necessity for shipping much of this coal to the upper Great Lakes region while navigation is still open has further created a tight situation in many low-volatile markets and consumers in such districts, as Detroit, are being urged to burn other coals. Plans are being made to ship additional quantities of high-volatile coal into these districts.

"It should be obvious to anyone who will consider the simple facts, that we face the necessity of lowering requirements, since it is currently impossible to increase production to the level of demand", says Mr. Ickes, "and this can be done only by conserving coal through using it as sparingly as possible. This fact must be thrust into the consciousness of every coal consumer if we are to avoid a great deal of hardship this winter."

Distribution of Used Equipment

A comprehensive program for redistribution to essential uses of upward of an estimated billion dollars worth of used or idle machinery and equipment, much of it now owned by the Government, has been announced by the War Production Board. This is to be a decentralized operation, conducted by the staffs of WPB Regional Offices. An innovation to be introduced by the program will be negotiated sales, under OPA price regulations, of government-owned equipment. Such sales will be made to ultimate users certified by WPB to be eligible to purchase.

Inventories of more than 55,000 types of machinery and equipment, available for purchase by anyone who qualifies under existing regulations applying to used or idle production equipment, will be filed in WPB Regional Offices. These inventories are being compiled from reports from used equipment dealers, voluntary listings by user-holders, the War Department, Treasury Procurement Division, Defense Plant Corporation and other government agencies. In all, some ten million pieces are expected to be listed, ranging from WPA sewing machines to industrial boilers and manufacturing equipment rendered idle by program changes.

When applications for authority to purchase new equipment are received by WPB field offices, they will be checked against the inventory lists and the applicant put in touch with owners of available equipment. When sales are consummated, following this procedure, they will be the result of negotiation between buyer and seller, subject only to OPA ceiling prices.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Electronic Heaters

Electronic heaters for heating metals are featured in a new, illustrated 8-page bulletin (GEA-4076) recently issued by the General Electric Company. The publication describes the electronic method of heating metals, emphasizes its simplicity and gives in detail the specifications of both the 5-kw and the 15-kw, 550-kc electronic heaters. Also included in the bulletin are illustrations of many important small parts which may be brazed, soldered or surface hardened by electronic heating.

Gasket Chart

An up-to-the-minute Gasket Chart showing the cross-sections of 36 most popular Gasket Types, their purposes and the characteristics which fit them for the specific services intended, is now available to interested engineers. This chart is featured in the second issue of "The Gasket"—a series of technical papers on gaskets compiled by the Research Laboratory of the Goetze Gasket and Packing Company, Inc. In requesting copies use your business letterhead and mention your position.

Heat Transmission Through Furnace Walls

Charts to simplify the solution of heat-transfer problems in connection with refractories and high-temperature insulation are contained in a new 16-page booklet published by The Atlas Lumnite Cement Company. Curves on the ten full-page charts are plotted in terms of conductivity factors. The novel arrangement makes it possible to use the charts for any refractory material for which the conductivity (K-factor) is known. The curves are calculated in accordance with A.S.T.M. "Recommended Procedure for Calculating Heat Loss through Furnace Walls." Information on the conductivity factors of some common refractory materials is given with remarks on the reliability of test data and their practical usefulness.

Open Steel Flooring

An unusual presentation of open steel flooring, gratings and safety steps is contained in a 24-page catalog just published by Kerlow Steel Flooring Company. This catalog, entitled "Industry's Magic Carpet," shows the proportions and construction of many designs of open steel flooring. Illustrations show the use of this construction for various special purposes such as armored flooring, bridge paving, power house floors, marine engine room floors and safety steps, sidewalk gratings, etc. A standard safe load table and sketch of a typical floor plan, together with complete dimensions of the various types of flooring and safety steps will assist engineers and construction men in selecting and laying out flooring for individual requirements.

Proportioning Equipment for Corrosive Fluids

Cochrane Corporation has issued a 4-page folder (No. 2985-A) which describes the principle of operation, applications and advantages of its air-activated type Proportioning Equipment for corrosive fluids. The bulletin is illustrated with halftones and line diagrams.

Remote Water Level Indicators

The Yarnall-Waring Company has issued an 8-page bulletin (WG 1820) describing the application and operating advantages of its Yarway Remote Water Level Indicator. This device permits reading the boiler water levels on an illuminated two-color scale mounted on the plant's instrument panel or other convenient location. The bulletin is profusely illustrated and shows the unique mechanism and the methods of installation.

Strainers for Marine Service

The construction and operation of Elliott Duplex and Macomb Strainers for marine service are detailed in a new 8-page bulletin (A-10) just issued by the Elliott Company. Sketches and dimension tables are given. A section on strainer baskets is included, with perforation, mesh and velocity charts. Other Elliott marine equipment is summarized on the back cover.

Turbine Type Pumps

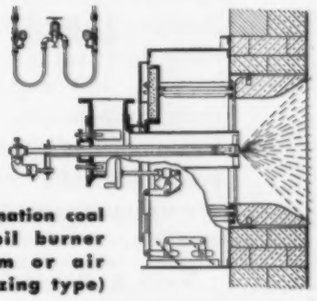
Westco Industrial Pumps Catalog (No. 43) is an attractive 60-page publication issued by Joshua Hendy Iron Works, Pomona Pump Co. Division. It is designed to give all the vital information concerning the company's line of industrial pumping units, condensation return units, automatic boiler feed units and Pomona vertical pumps, together with details of design, operating characteristics and several pages of useful engineering data. An outstanding feature of the book is the abundance of large duotone illustrations and blueprint dimension drawings and diagrams.

Enco
OIL BURNERS
have these
7 ADVANTAGES
in pulverized coal fired boilers . . .

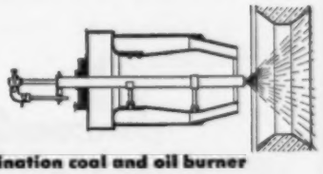
They may be installed in practically all types of pulverized coal burners, with these seven important advantages:

- They warm up cold furnaces
- They ignite pulverized coal—safely
- They assure continuous operation in case coal system fails
- They provide efficient and safe operation on bank and at low loads
- They respond almost instantly to sudden load changes
- They permit operation with oil or coal—whichever is available and lowest in cost per BTU.
- All capacities of steam, air or mechanical-atomizing types are interchangeable

The foregoing are only a few of the reasons why Enco oil-burners have been bought by a long list of leading industrial firms. Details of how Enco oil-burners can be adapted to your present pulverized coal burners will be gladly supplied—without obligation. Write The Engineer Company, 75 West St., New York, N. Y.

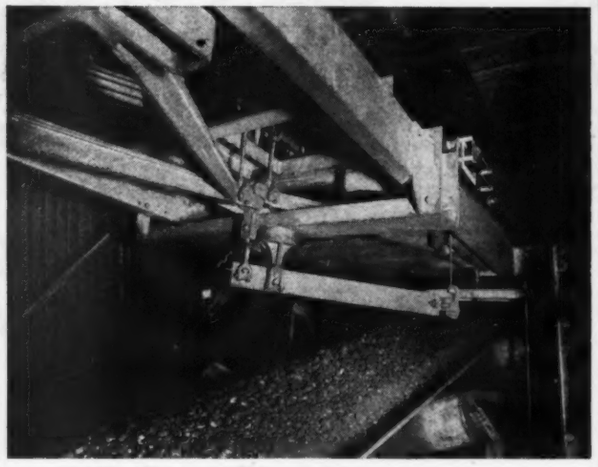


Combination coal and oil burner (Steam or air atomizing type)



Combination coal and oil burner (Mechanical atomizing type)

Enco Burners



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Sincerely Yours,

BUILDERS - PROVIDENCE

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Careysel Insulations
For temperatures up to 300° F.

85% Magnesia
For High and Medium Pressure.

Cut Production Costs

Many industrial plants are saving thousands of fuel dollars each year through the correct application of CAREY Heat Insulations . . . a complete line of high efficiency insulating materials of Asbestos and Magnesia for every known service condition—for temperatures ranging from

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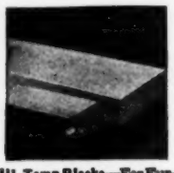
Put your special problems up to Carey Engineers . . . their experience and Carey research facilities are available through branch offices covering the nation. Write for Insulation Catalog. Address Dept. 69.

Combination Hi-Temp—85% Magnesia.



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